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ABSTRACT

Designed for use in industrial education programs at the secondary school level, this unit focuses on residential space heating although applications can be made to commercial settings. Wood heat is emphasized but coal-fired appliances and other energy sources are considered. Educational objectives with instructional strategies are provided for each of the eight major concepts addressed. These concept areas include: (1) fuels; (2) solid fuel heating appliance design; (3) chimneys and flues; (4) safety regulations; (5) solid fuel appliance installation; (6) heating system management and maintenance; (7) occupations; and (8) environmental considerations. A basic competency profile chart and checklist is provided for the addressed skill areas. The bibliographic section contains sources of publications, media, and 20 transparency masters. (ML)

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NEW JERSEY VOCATIONAL-TECHNICAL CURRICULUM LABORATORY
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HEATING WITH SOLID FUELS

a Unit of Instruction

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November 1982

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Project staff and participants look forward to your use of these pilot materials and hope you will feel free to suggest improvements.

Robert D. Weber
Project Director
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FOREWORD

This document is one of four produced for the New Jersey Division of Vocational Education and Career Preparation by the Center for Energy Conservation at Trenton State College, Trenton, New Jersey. In addition to the four documents, four filmstrip/cassettes were also produced. The written documents and media packages deal with one of the following technologies:

1. Solar Heated Domestic Hot Water Systems
2. Solar Heated Space Systems
3. Wind Energy Conversion Systems
4. Heating with Solid Fuels

Curriculum materials were produced over a six month period by selected secondary school, industrial education teachers whose efforts were coordinated by a consultant from one of the state colleges. In all cases, both the teachers and the college consultant who served as the group leader, were selected for their experience and expertise in the particular technology being addressed. The filmstrip/cassette packages were developed and produced by technicians from the Center for Energy Conservation. The preliminary scripts were carefully reviewed and edited by the college consultants, project director and an industrial representative before being finalized.

During the 1980-81 school year each one of the units of instruction was pilot tested in a selected industrial education program within the State of New Jersey.

Further information regarding the availability of these curriculum materials can be obtained by writing to the address listed below:

Vocational-Technical Curriculum Lab
Rutgers - The State University of New Jersey
Building 4103 - Kilmer Campus
New Brunswick, New Jersey 08903

GUIDE FOR USING THIS DOCUMENT

This document attempts to organize a complex body of knowledge into teachable units. Information in the document has been arranged so that the reader is first exposed to the "big picture" or framework of the area under discussion. From this point, the reader is then gradually introduced to the component parts of the package. This is accomplished by arranging the information in the following manner:

INTRODUCTION

The introduction provides the reader with basic information regarding the design and application of the curricular materials contained in the document.

UNIT OVERVIEW

The unit overview identifies the major concepts to be covered along with a brief description of the subject matter related to each major concept. A suggested period of time for teaching the subject matter has also been included in the unit overview.

CONCEPT OUTLINE OVERVIEW

In this section the reader can examine more extensively a taxonomy or subject-matter outline of all major concepts. The outline provides a complete listing of concepts to be covered along with suggested teaching times. Most of the major concepts are outlined to the third level by using the numerical system listed below:

1.0 Designates a major or first-level concept.
1.1 Designates a second-level concept.
1.1.1 Designates a third-level concept.

EDUCATIONAL OBJECTIVES

Educational objectives for each major concept are grouped together and can be located by referring to the Table of Contents. Educational objectives, derived from the third level concepts, are numbered accordingly. For example, a third-level concept (1.1.1) might have two objectives which would, therefore, be numbered as 1.1.1.1 and 1.1.1.2.

EDUCATIONAL OBJECTIVES WITH INSTRUCTIONAL STRATEGIES

In this section each page focuses on a specific third-level concept. The third-level concept will be identified in relationship to the second- and first-level concepts in order to maintain continuity. Educational objectives related to the third-level concept will then be listed. Finally, suggested instructional strategies which can be used to accomplish the listed objectives are recorded. The strategies are labeled a, b, c, etc. and can be used individually by the teacher or grouped together to

facilitate accomplishing the listed objectives.

EVALUATION

This section provides suggestions for evaluating how much has been learned and the degree to which objectives have been accomplished.

BIBLIOGRAPHY

The bibliography serves as a resource guide and contains the following:

1. Overhead Transparency Masters
   These masters can be used to make overhead transparencies. In most instances, each transparency master has been identified for use with a particular instructional strategy.

2. Publications/References
   A list of books and magazines which pertain to the subject matter or relate to an instructional strategy are included in this section. References made to publications in the text of this document are abbreviated for the sake of brevity and the reader is requested to check the bibliography for a more complete documentation.

3. Films, Slides, and Filmstrips
   A list of instructional media which could be used for instruction is included in this section.

   Here again, media referred to in the text of this document are abbreviated and the reader should check the bibliography for more complete documentation.

INTRODUCTION
Heating with Solid Fuels

This unit of instruction, heating with solid fuels, has been designed for use in industrial education programs at the secondary school level. The information in this instructional package is not a textbook. Rather, it is a collection of guidance information and teaching recommendations primarily for use by the teacher. This unit focuses on residential space heating although similar principles could easily be applied to commercial applications. Wood heat is emphasized but coal-fired appliances as well as other energy sources are also considered.

It is expected that the teacher has amassed an adequate body of information about the subject, prior to undertaking the teaching of this unit. While no single published book on solid fuel heating, usually called wood heating, provides the coverage that this curriculum ideally entails, several such books are noted as "general information" books in the bibliography of this syllabus. These books could be considered textbooks if the teacher feels a text would be beneficial, particularly for use by students.

The course has been set up so that satisfactory learning results are expected by teaching the subject matter in the order presented. However, equally effective learning could probably result if the teacher chose to rearrange the topical sequence of presentation.

While the student learning objectives are deemed to be the ideal outcomes of the curriculum, here too, individual expertise of the teacher coupled with teaching time constraints and other factors could dictate alteration of the objectives.

On the other hand, the recommended strategies often present more than one way to provide the same or at least a similar learning opportunity for the student. Further, some of the strategies could not possibly be accomplished in the recommended time. They were included because teachers find that different approaches to teaching are required for different groups.

The total instructional time required for this unit is about 28 hours. However, the times listed are flexible and because of time requirements of some strategies, selection of the best strategy to employ will depend on individual teacher preference, available time, class size, student maturity, and available resources.

It is our hope that the use of this unit of instruction will foster the efficient and safe use of solid fuel burning appliances.

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UNIT OVERVIEW
Heating with Solid Fuels

1.0 Fuels Suggested Instructional Time--4 hours, 15 minutes	Various fuels are used to warm our homes. This unit will examine relative costs of fuels, their cleanliness, abundance, availability, storage and combustion characteristics. Special consideration is also given to the safe use of various fuels.
2.0 Solid Fuel Heating Appliance Design Suggested Instructional Time--4 hours	Appliances for burning solid fuels are compared in the following areas: types, design features, efficiency and heat distribution techniques. Appliances compared are fireplaces, metal stoves and multi-fuel furnaces. Proper location and size of the appliance relative to the configuration of the home are evaluated.
3.0 Chimneys and Flues Suggested Instructional Time--3 hours	The types, selection, principles of operation and techniques of installation of metal and masonry flues and chimneys are highlighted. Aesthetics, the advantages and disadvantages and the location and dimensions of chimneys are also covered.
4.0 Safety Recommendations, Regulations, Codes and Laws Suggested Instructional Time--1 hour, 40 minutes	Scrutiny of manufacturer's recommendations for installation and operation, examination of municipal through federal recommended or required standards, obtaining installation and use permits, safe installation clearances together with preventative maintenance and fire insurance implications of the heating system comprise this unit on safety and codes.
5.0 Installation of Solid Fuel Appliances Suggested Instructional Time--4 hours, 15 minutes	Installation of solid fuel appliances requires carpentry, masonry and metal speciality skills. Selected hand and power tools must be identified and used correctly. Following manufacturer's specifications and an understanding of flammable and non-flammable components are important. Following

	these prerequisites, procedures for installation of heating appliances are developed.
6.0 Management and Maintenance of the Heating System Suggested Instructional Time--3 hours, 15 minutes	Management and maintenance of a heating system entails wise operation. Knowledge of maintenance requirements and durability of components are conveyed. To maximize heat potential, home insulation and weather sealing is briefly covered.
7.0 Occupations Suggested Instructional Time--2 hours, 30 minutes	Careers in heating are numerous and include installation, maintenance, sales and regulatory areas. An appreciation for the breadth of career potential plus a knowledge of training and educational requirements are presented.
8.0 Environmental Considerations Suggested Instructional Time--2 hours, 30 minutes	Environmental constraints will continue to shape our life activities. Home heating is shown to be a powerful effector of environmental change. The benefits of use of renewable fuels and coal are weighed against environmental impact of solid fuel technology.

Total Instructional Time: 27 hours, 55 minutes

CONCEPT OUTLINE
Heating with Solid Fuels

1.0	FUELS	4 hrs 15 mins
1.1	Types	1 hr 15 mins
1.1.1	Wood	35 mins
1.1.2	Coal	30 mins
1.1.3	Others	10 mins
1.2	Economics for Use	1 hr
1.2.1	Energy of Fuel Types	20 mins
1.2.2	Costs vs. Heat Production	10 mins
1.2.3	Cleanliness and Ease of Use	15 mins
1.2.4	Abundance and Local Availability of Fuels	15 mins
1.3	Combustion	1 hr 10 mins
1.3.1	Stages	20 mins
1.3.2	Requirements for Efficient Combustion	20 mins
1.3.3	Burning Characteristics of Fuel	30 mins
1.4	Storage	40 mins
1.4.1	Wood Drying and Ricking	20 mins
1.4.2	Coal	10 mins
1.4.3	Other Fuels	10 mins
1.5	Safety	10 mins
2.0	SOLID FUEL HEATING APPLICANCE DESIGN	4 hrs
2.1	Types of Appliances	50 mins
2.1.1	Fireplaces	15 mins
2.1.2	Metal Stoves	20 mins
2.1.3	Multi-fuel Furnaces	15 mins
2.2	Design Features for Combustion	1 hr
2.2.1	Fireplaces	25 mins
2.2.2	Metal Stoves	25 mins
2.2.3	Multi-fuel Furnaces	10 mins
2.3	Appliance Efficiency	40 mins
2.3.1	Fireplaces	10 mins
2.3.2	Metal Stoves	15 mins
2.3.3	Multi-fuel Furances	15 mins

2.4	Heat Distribution Techniques	1 hr
2.4.1	Radiant	15 mins
2.4.2	Convection	10 mins
2.4.3	Circulation-Forced Air	15 mins
2.4.4	Circulation-Hydronic	20 mins
2.5	Location and Sizing	30 mins
3.0	CHIMNEYS AND FLUES	3 hrs
3.1	Types	30 mins
3.1.1	Metal	15 mins
3.1.2	Masonry	15 mins
3.2	Selection of Proper Flue	20 mins
3.2.1	Advantages of Types	10 mins
3.2.2	Disadvantages of Types	10 mins
3.3	Principles of Operation	20 mins
3.3.1	Draft	10 mins
3.3.2	Dimensions	10 mins
3.4	Techniques of Installation	1 hr 50 mins
3.4.1	Aesthetics	30 mins
3.4.2	Location	20 mins
3.4.3	Masonry Flues	30 mins
3.4.4	Metal Flues	30 mins
4.0	SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS	3 hrs 10 mins
4.1	Manufacturer's Recommendation	30 mins
4.1.1	Installation	15 mins
4.1.2	Operation	15 mins
4.2	Municipal Building Codes	10 mins
4.2.1	Obtaining Pertinent Installation/Use Permits	10 mins
4.3	National Standards	30 mins
4.3.1	Agencies and Organizations: UL, BOCA, NFPA	10 mins
4.3.2	Regulations for Safe Appliance Installation: Clearances	20 mins
4.4	Preventative Maintenance and Safety	20 mins
4.4.1	Chimney Fires	10 mins
4.4.2	Appliance Faults	10 mins

4.5	Fire Insurance Implications	10 mins
5.0	INSTALLATION OF SOLID FUEL APPLIANCES	4 hrs 15 mins
5.1	Skills Required	25 mins
5.1.1	Carpentry	10 mins
5.1.2	Masonry	15 mins
5.1.3	Metalworking	10 mins
5.2	Tools Required	20 mins
5.2.1	Hand Tools	10 mins
5.2.2	Power Tools	10 mins
5.3	Materials	45 mins
5.3.1	Fireproof Materials	15 mins
5.3.2	Fire Resistant/Retardant Materials	15 mins
5.3.3	Flammable Materials	15 mins
5.4	Procedure	2 hrs 35 mins
5.4.1	Fireplace	30 mins
5.4.2	Fireplace with Heat Circulator	35 mins
5.4.3	Metal Stove on and Near Combustible Surface	45 mins
5.4.4	Multi-fuel Systems	45 mins
6.0	MANAGEMENT AND MAINTENANCE OF THE HEATING SYSTEM	3 hrs 15 mins
6.1	Wise Appliance Operation	1 hr
6.1.1	Daily Through Yearly Maintenance	30 mins
6.1.2	Preventative Maintenance	30 mins
6.2	Maintaining the Chimney and Flue	1 hr 15 mins
6.2.1	Durability of Types	30 mins
6.2.2	Inspecting Old Chimneys	15 mins
6.2.3	Cleaning Techniques	30 mins
6.3	Keeping Heat Inside the House	1 hr
6.3.1	Heat Distribution	20 mins
6.3.2	Outside Air Infiltration	20 mins
6.3.3	Insulation	20 mins
7.0	OCCUPATIONS	2 hrs 30 mins
7.1	Installation	30 mins
7.1.1	Trades People	15 mins
7.1.2	Specialty Installer	15 mins

7.2	Maintenance	15 mins
7.2.1	Trades People	15 mins
7.3	Sales	1 hr
7.3.1	Construction Materials	10 mins
7.3.2	Burning Appliances, Flues	10 mins
7.3.3	Replacement Equipment	15 mins
7.3.4	Maintenance Equipment and Supplies	10 mins
7.3.5	Fuels	15 mins
7.4	Regulatory and Monitor Personnel	45 mins
7.4.1	Local Through Federal	45 mins
8.0	ENVIRONMENTAL CONSIDERATIONS	2 hrs 30 mins
8.1	Renewable Resources	20 mins
8.1.1	Common Hardwood Trees	10 mins
8.1.2	Wood Lot Management	10 mins
8.2	Non-Renewable Resources	10 mins
8.2.1	Environmental Impact of Coal Mining, Processing, etc.	10 mins
8.3	Pollution from Burning	1 hr 30 mins
8.3.1	Smoke Effects	15 mins
8.3.2	Carbon Dioxide and Greenhouse Effects	30 mins
8.3.3	Effects of Noxious Gases	15 mins
8.3.4	Acid Rain Effects	15 mins
8.3.5	Coal Ashes	15 mins
8.4	Conservation Aspects	30 mins
8.4.1	Wood or Coal vs. Gas or Fuel Oil	15 mins
8.4.2	Uses for Wood and Coal Ashes	15 mins

CONCEPT 1.0

FUELS

MAJOR CONCEPT 1.0 - FUELS

EDUCATIONAL OBJECTIVES

The following objectives provide the teacher with an overview of the concepts and skills contained in this section.

The student will be able to:

1.1.1.1 differentiate between 15 common hardwoods and softwoods.

1.1.1.2 orally explain three means of obtaining wood or its by-products for fuel.

1.1.2.1 write a brief history of coal use in America from the 1700's to the present.

1.1.2.2 name three types of coal and list the advantages of anthracite coal over softer (bituminous) coal.

1.1.3.1 name oil, gas and other non-solid fuels which are used for home heating.

1.1.3.2 identify advantages and disadvantages of the fuels which are not in the solid fuel category.

1.2.1.1 list potential energy of wood, coal, gas, etc., per unit of conventional volumetric measurement.

1.2.1.2 recognize how and why wet firewood has reduced potential for heat output.

1.2.2.1 determine cost per unit of conventional volumetric measurement for wood, gas, oil and coal at current prices.

1.2.2.2 determine cost per unit for alternate fuels at current prices.

1.2.3.1 describe the pros and cons of burning different fuels.

1.2.3.2 describe for each common home heating fuel type (wood, oil, coal, gas) the problems with bulk, leakage and cleanliness during storage.

1.2.4.1 rank fuels from most abundant to least abundant.

1.2.4.2 distinguish between renewable and non-renewable fuels and know which are most readily available locally.

1.3.1.1	identify the stages of combustion.
1.3.2.1	list requirements for efficient combustion to occur.
1.3.3.1	identify the important burning characteristics of wood, coal, oil and gas.
1.3.3.2	differentiate between good and poor types of firewood and coal.
1.4.1.1	explain why it is necessary to store wood properly and same three methods for storage.
1.4.1.2	sketch a simple, inexpensive storage structure for firewood and point out its best features.
1.4.2.1	identify the requirements for coal storage in and nearby the home.
1.4.2.2	list the pros and cons of coal use, storage and handling.
1.4.3.1	identify storage techniques and problems or benefits, particularly as they refer to fuel oil.
1.5.1	identify the hazards of fuels especially wood and coal and the precautions that must be taken when using them.

MAJOR CONCEPT 1.0 FUELS **TIME** 35 mins.

1.1 Types

1.1.1 Wood

OBJECTIVES	STRATEGIES
1.1.1.1 Differentiate between 15 common hardwoods and softwoods	a. Provide samples of split hardwood and softwood including the bark.
1.1.1.2 Orally explain three means of obtaining wood or its by-products for fuel.	b. Demonstrate the use of the chain saw, ax, sledge hammer and wedge, bow saw and log splitter.*
	c. Have students brainstorm various industries that might produce wood scraps suitable for use as fuel.

NOTES:

*Use adequate safety precautions such as goggles, ear, foot and hand protection. See also 16 mm film "Chain Saws and Common Sense--A Guide for People with Both," Stihl Corp.

MAJOR CONCEPT 1.0 FUELS **TIME** 30 mins

1.1 Types

1.1.2 Coal

OBJECTIVES	STRATEGIES
1.1.2.1 Write a brief history of coal use in America from the 1700's to the present.	a. Illustrated lecture on historical use of coal: include coal types and advantages of hard coal over soft coal. Transparency #1.
1.1.2.2 Name three types of coal and list the advantages of anthracite coal over softer (bituminous) coal.	b. Burn* a sample of hard coal and one of soft coal. Note the burning temperature, time of burning, smoke and odors produced.

NOTES:

*A given quantity of coal should be compared. Toxic gases can be given off so adequate ventilation or precautions must be exercised. Use adequate fire and heat precautions.

MAJOR CONCEPT 1.0 FUELS **TIME** 10 mins

1.1 Types

1.1.3 Others

OBJECTIVES	STRATEGIES
1.1.3.1 Name oil, gas and other non-solid fuels which are used for home heating.	a. Survey the class to determine home heating fuel usage and prepare a chart summarizing the information.
1.1.3.2 Identify advantages and disadvantages of the fuels which are not in the solid fuel category.	b. Assemble magazine and newspaper articles on new energy sources. c. Make a bulletin board to show various types of fuels. d. Brainstorm with students advantages and disadvantages of fuels identified in "a" above.

NOTES:

MAJOR CONCEPT 1.0 FUELS **TIME** 20 mins.

1.2 Economics for Use

1.2.1 Energy of Fuel Types

OBJECTIVES	STRATEGIES
1.2.1.1 List potential energy of wood, coal, gas, etc., per unit of conventional volumetric measurement.	a. Use a calorimeter to measure the heat output* of various fuels. Standardize the amounts: i.e., 1 lb of solid fuel, 0.1 gal of liquid fuel.
1.2.1.2 Recognize how and why wet firewood has reduced potential for heat output.	b. Prepare charts on relative heat outputs of fuels and a chart which compares wet and dry wood.**
	c. Give illustrated lecture comparing available energy in different types of fuels. Transparency #2.

NOTES:

*Use adequate precautions due to heat and flames and noxious gases which can be generated.

**R.C. Dorf, Energy Resources and Policy.

MAJOR CONCEPT 1.0 FUELS **TIME** 10 mins.

1.2 Economics for Use

1.2.2 Cost vs. Heat Production

OBJECTIVES	STRATEGIES
1.2.2.1 Determine cost per unit of conventional volumetric measurement for wood, gas, oil and coal at current prices.	a. Contact fuel/energy suppliers for current energy cost quotes (per cord, KWH, therm, gallon, ton).
1.2.2.2 Determine cost per unit for alternate fuels at current prices.	b. Have students compare heating energy costs for their homes based on cubic feet of living space.*

NOTES:

*See J. Shelton and A. Shapiro, The Woodburners Encyclopedia, pp. 88-89, for discussion on economics of different fuels.

MAJOR CONCEPT 1.0 FUELS **TIME** 15 mins.

1.2 Economics for Use

1.2.3 Cleanliness and Ease of Use

OBJECTIVES	STRATEGIES
1.2.3.1 Describe the pros and cons of burning different fuels.	a. Demonstrate how easily ashes of coal and wood become airborne.
1.2.3.2 Describe for each common home heating fuel type (wood, oil, coal, gas) the problems with bulk, leakage and cleanliness during storage.	b. Demonstrate how smothered wood fires and certain fuel oil flames can give off much smoke and soot.*
	c. Demonstrate the cleanliness of gas by directing a propane torch flame to a clean metal plate.
	d. Discuss problems with bulk, dirt, leakage and safety during storage of fluids.
	e. Have students brainstorm disadvantages/advantages of various fuels.

NOTES:

*Exercise adequate safety (flame hazard plus noxious gases).

MAJOR CONCEPT 1.0 FUELS **TIME** 15 mins.

1.2 Economics for Use

1.2.4 Abundance and Local Availability of Fuels

OBJECTIVES	STRATEGIES
1.2.4.1 Rank fuels from most abundant to least abundant. 1.2.4.2 Distinguish between renewable and non-renewable fuels and know which are most readily available locally.	a. Show a map of locations of various fuels and describe how they are moved to market. b. Discuss current and projected supplies of various fuels and known reserves. c. Have students list fuels on chalkboard and identify each as renewable or non-renewable. d. Show a time chart explaining the expected time for depletion of different fuels. Transparency #3.

NOTES:

MAJOR CONCEPT 1.0 FUELS **TIME** 20 mins.

1.3 Combustion

1.3.1 Stages

OBJECTIVES	STRATEGIES
1.3.1.1 Identify the stages of combustion.	a. Build a fire* of wood and show the various stages. b. Illustrated lecture on the three stages of combustion. Transparency. #4**.

NOTES:

*Properly vent the fire or build it outside with adequate precautions. A small grill and scraps of lumber could be used for this demonstration.

**For discussion of coal combustion see NFPA, Using Coal and Wood Stoves Safely, p. 9.

MAJOR CONCEPT 1.0 FUELS **TIME** 20 mins.

1.3 Combustion

1.3.2 Requirements for Efficient Combustion

OBJECTIVES	STRATEGIES
1.3.2.1 List requirements for efficient combustion to occur.	a. Use class discussion and lecture to describe requirements for efficient combustion. b. Use a small airtight stove* (pot belly or box stove) to demonstrate problems of burning with wet wood, too much draft, too little oxygen and other parameters the particular system will permit to be shown.

NOTES:

*Use adequate safety precautions and select an applicance which is approved by a national testing laboratory and/or approved by the local building inspector/fire inspector.

MAJOR CONCEPT 1.0 FUELS **TIME** 30 mins.

1.3 Combustion

1.3.3 Burning Characteristics of Fuels

OBJECTIVES	STRATEGIES
1.3.3.1 Identify the important burning characteristics of wood, coal, oil and gas. 1.3.3.2 Differentiate between good and poor types of firewood and coal.	a. Illustrated lecture on combustion differences of fossil fuels. b. Using a suitable stove,* make the following comparisons: a. amount of ash (use known amount of fuel and weigh ashes). b. amount of heat (use pyrometer). c. amount of smoke produced under best/worst burning conditions. d. spark and flame hazards. c. Illustrated lecture on burning characteristics of different types of coal and wood. Transparency #5.

NOTES:

*Use adequate safety precautions to avoid flame and noxious gas dangers.

MAJOR CONCEPT 1.0 FUELS **TIME** 20 mins.

1.4 Storage

1.4.1 Wood Drying and Ricking

OBJECTIVES	STRATEGIES
1.4.1.1 Explain why it is necessary to store wood properly and name three methods for storage.	a. Show samples of wood: one year of proper seasoning, one year on the ground with mildew, moisture and insect infestation.
1.4.1.2 Sketch a simple, inexpensive storage structure for firewood and point out its best features.	b. Use models/plans to show storage and stacking methods for wood.*
	c. Hand out plans for a simple wood storage shed.
	d. List present costs for building materials for a shed.
	e. Conduct a production project** to make simple storage facilities (shed, log hoop, etc.).

NOTES:

*See NRAES, Burning Wood, p. 5.
**Use adequate precaution about proper tool usage and safety.

MAJOR CONCEPT 1.0 FUELS **TIME** 10 mins.

1.4 Storage

1.4.2 Coal

OBJECTIVES	STRATEGIES
1.4.2.1 Identify the requirements for coal storage in and nearby the home.	a. Discuss the problems of coal storage and how they are best resolved.*
1.4.2.2 List the pros and cons of coal use, storage and handling.	b. List on the board the pros and cons of coal usage, storage and handling.*

NOTES:

*See J.S. Kane, Burning Coal Efficiently.

MAJOR CONCEPT 1.0 FUELS **TIME** 10 mins.

1.4 Storage

1.4.3 Other Fuels

OBJECTIVES	STRATEGIES
1.4.3.1 Identify storage techniques and problems or benefits, particularly as they refer to fuel oil.	a. Discuss how gas and fuel oil are stored. b. Show pictures of floor plans of homes to identify possible aesthetic and safety considerations for placement of tanks. c. Explain about rusting, leakage and possible pollution of soil and underground water.

NOTES:

MAJOR CONCEPT 1.0 FUELS **TIME** 10 mins.

1.5 Safety

OBJECTIVES	STRATEGIES
1.5.1 Identify the hazards of fuels especially wood and coal and the precautions that must be taken when using them.	a. Caution students about proper handling of fuels, burns and noxious gases. b. Where manual skills are employed caution students about improper techniques in tool and material usage. Conversely, relate the proper handling of equipment and materials. c. Note precautions for storing coal.*

NOTES:

*See NFPA, Using Wood and Coal Stoves Safely, p. 10.

CONCEPT 2.0

APPLIANCE DESIGN

MAJOR CONCEPT 2.0 - SOLID FUEL HEATING APPLIANCE DESIGN

EDUCATIONAL OBJECTIVES

The following objectives provide the teacher with an overview of the concepts and skills contained in this section.

The student will be able to:

2.1.1.1 recognize basic fireplace designs and the fact that openess of the firebox to the room's living space actually defines a fireplace.

2.1.2.1 classify metal stoves, according to the material used to construct them. (Plate steel, sheet steel, cast iron.)

2.1.2.2 name four of the most popular basic types of metal stoves used today and sketch their basic shapes.

2.1.3.1 define a multi-fuel furnace.

2.1.3.2 list fuels routinely used in multi-fuel furnaces.

2.2.1.1 explain the value of the "smoke shelf" and walls of fireplaces (if present) as smoke and heat directing structures.

2.2.1.2 show through drawings, why the Rumford type of fireplace is superior to most others.

2.2.1.3 using sketches, recommend dimensions of the fireplace opening, firebox size, smoke shelf and damper size for standard masonry fireplaces.

2.2.1.4 explain that all fireplaces require large amounts of air for combustion and therefore have a draft which is greater than other heating appliances.

2.2.2.1 explain differences and similarities in the burning operation (combustion properties) of airtight and non-airtight stoves.

2.2.2.2 understand combustion features (such as primary and secondary draft, flame path, and thermal mass) of wood burning by sketching a cutaway and labeling the special combustion features.

2.2.3.1 describe the operation of multi-fuel furnaces and list the major parts.

2.3.1.1 state the efficiency of various types of open fireplaces.

2.3.1.2 name four methods or products which increase the efficiency of a fireplace.

2.3.2.1 state the range of efficiency for airtight and non-airtight metal stoves.

2.3.2.2 explain the relationship between combustion efficiency, flue temperature and creosote build-up.

2.3.2.3 list advantages/disadvantages of cast iron versus plate steel for stoves.

2.3.2.4 explain the value of increased thermal mass imparted by fire bricks in a wood stove.

2.3.3.1 recognize the relative efficiencies of the solid fuel and liquid/gas fuel components of multi-fuel system.

2.3.3.2 explain the advantage of separate combustion chambers for the two fuels.

2.3.3.3 explain how design features of a stove largely dictate efficiency.

2.4.1.1 define radiative heat transfer and explain why radiant heat "feels" so comfortable.

2.4.1.2 list three manufacturers of stoves which heat principally by radiation.

2.4.2.1 define convection.

2.4.2.2 explain how convection is an aspect of all heat distribution techniques in the home.

2.4.3.1 understand that heated air rises, cools and falls in circulation patterns.

2.4.3.2 diagram and label the parts of solid fuel forced air circulating stove.

2.4.3.3 explain in writing how active circulation (as with a blower) increases heating efficiency by increasing the net flow of heat from the heating appliance to the living space.

2.4.4.1 explain how hydronic heating is a combination of all the other heat distribution techniques.

2.4.4.2 diagram and label a simple single loop hydronic heating system.

2.5.1 estimate the maximum wintertime B.T.U./hr requirement for an average home (16,000 cu. ft. of living space) and relate this to heating appliances on the market.

2.5.2 using floor plans of a rancher and a two-story colonial home, select and defend the selection of ideal and inferior locations for a fireplace, circulating/radiative air-tight stove and a hydronic heating unit.

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 15 mins

2.1 Types of Appliances

2.1.1 Fireplaces

OBJECTIVES	STRATEGIES
2.1.1.1 Recognize basic fireplace designs and the fact that openness of the firebox to the room's living space actually defines a fireplace.	a. Show pictures or diagrams of different kinds of fireplaces. See K. Kern and S. Magers, Fireplaces, 1978. b. Discuss the fireplace types shown. Try to draw upon the students' own experience with fireplaces in their homes.

NOTES:

MAJOR CONCEPT 2.0 SOLID FUELS HEATING APPLIANCE DESIGN **TIME** 20 mins.

2.1 Types of Appliances

2.1.2 Metal Stoves

OBJECTIVES	STRATEGIES
2.1.2.1 Classify metal stoves, according to the material used to construct them. (Plate steel, sheet steel, cast iron.) 2.1.2.2 Name four of the most popular basic types of metal stoves used today and sketch their basic shapes.	a. Show transparency illustrating various types of metal stoves.* Transparency #6. b. Lecture on the popularity and relative cost of each metal stove type, pointing out advantages/ disadvantages of cast iron vs. steel. c. Discuss any personal experience students have had with metal stoves.

NOTES:

*Stoves can be variously classified, e.g. Steel or Cast iron, Radiant or Convection, air tight or non-air tight, room where stove is located, draft patterns, etc.

MAJOR CONCEPT 2.0 SOLID FUELS HEATING APPLIANCE DESIGN **TIME** 15 mins.

2.1 Types of Appliances

2.1.3 Multi-fuel Furnaces

OBJECTIVES	STRATEGIES
2.1.3.1 Define a multi-fuel furnace. 2.1.3.2 List fuels routinely used in multi-fuel furnaces.	a. Show cutaway views and pictures of multi-fuel furnaces.* b. Lecture on the popular fuel combinations in use today. c. Discuss any personal experience students have with multi-fuel furnaces.

NOTES:

*See V.D. Chase, Multi-Fuel Furnaces, 1979.

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLICANCE DESIGN **TIME** 25 mins.

2.2 Design Features for Combustion

2.2.1 Fireplaces

OBJECTIVES	STRATEGIES
2.2.1.1 Explain the value of the "smoke shelf" and walls of fireplaces (if present) as smoke and heat directing structures.	a. Diagrams of fireplace dimensions and configurations should be used to teach the proper design for best combustion.
2.2.1.2 Show through drawings, why the Rumford type of fireplace is superior to most others.	b. Show pictures of a few popular types, including the "Count Rumford" type to reveal how similar they look yet how the specific dimensions and interior configurations differ or are alike. Transparency #7.
2.2.1.3 Using sketches, recommend dimensions of the fireplace opening, fire box size, smoke shelf and damper size for standard masonry fireplaces.	c. Discuss the mechanics of wood burning in a fireplace.
2.2.1.4 Explain that all fireplaces require large amounts of air for combustion and therefore have a draft which is greater than other heating appliances.	

NOTES:

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 25 mins.

2.2 Design Features for Combustion

2.2.2 Metal Stoves

OBJECTIVES	STRATEGIES
2.2.2.1 Explain differences and similarities in the burning operation (combustion properties) of airtight and non-airtight stoves.	a. Make a bulletin board showing special design features for combustion. b. Guide students in production of cardboard models of stoves.
2.2.2.2 Understand combustion features (such as primary and secondary draft, flame path, and thermal mass) of wood burning by sketching a cutaway and labeling the special combustion features.	c. Provide cutaway sketches of popular metal stoves with the requirement of students' labeling of certain parts of the stoves. d. Lecture on the importance of high temperature for effective burning of gases during the secondary combustion stages.

NOTES:

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLICANCE DESIGN **TIME** 10 mins.

2.2 Design Features for Combustion

2.2.3 Multi-fuel Furnaces

OBJECTIVES	STRATEGIES
2.2.3.1 Describe the operation of multi-fuel furnaces and list the major parts.	a. Discuss with class, the design features of multi-fuel furnaces.* b. Have students request literature from manufacturers of multi-fuel furnaces.*

NOTES:

*See V.C. Chase, Multi-fuel Furnaces for discussion on design features and a list of manufacturers.

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 10 mins.

2.3 Appliance Efficiency

2.3.1 Fireplaces

OBJECTIVES	STRATEGIES
2.3.1.1 State the efficiency of various types of open fireplaces. 2.3.1.2 Name four methods or products which increase the efficiency of a fireplace.	a. Discuss with students the reasons for low thermal efficiency of open fireplaces and ask them to list devices which could be used to increase thermal efficiency.*

NOTES:

*See F.S. Langa, Identifying Woodburners by Type for a discussion of stove/fireplace efficiencies and devices designed to increase fireplace efficiency.

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 15 mins

2.3 Appliance Efficiency

2.3.2 Metal Stoves

OBJECTIVES	STRATEGIES
2.3.2.1 State the range of efficiency for airtight and non-airtight metal stoves. 2.3.2.2 Explain the relationship between combustion efficiency, flue temperature and creosote build-up. 2.3.2.3 List advantages/disadvantages of cast iron versus plate steel for stoves. 2.3.2.4 Explain the value of increased thermal mass imparted by fire bricks in a wood stove.	a. Lecture on stove efficiency and factors influencing it. b. Operate an airtight stove in class using variables which can reduce or increase efficiency and also influence creosote build-up: little secondary air draft vs. much; dry vs. wet wood, etc.* c. Heat up equal sized pieces of plate steel and cast iron to measure warpage, heat absorption and heat release properties. When cool, compare strength.* d. Lecture on the value of increased thermal mass of a stove.

NOTES:

*Use adequate safety precautions.

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 15 mins.

2.3 Appliance Efficiency

2.3.3 Multi-fuel Furnaces

OBJECTIVES	STRATEGIES
2.3.3.1 Recognize the relative efficiencies of the solid fuel and liquid/gas fuel components of multi-fuel system. 2.3.3.2 Explain the advantage of separate combustion chambers for the two fuels. 2.3.3.3 Explain how design features of a stove largely dictate efficiency.	a. Hand out a chart on relative efficiencies of solid fuel and liquid/gas fuel components of a multi-fuel system. b. Lecture on advantages of separate combustion chambers. c. Review design and combustion features which increase efficiency.

NOTES:
The Popular Science index is a handy guide for science ideas on pop science issues.

MAJOR CONCEPT 2.0 SOLID FUELD HEATING APPLIANCE DESIGN **TIME** 15 mins.

2.4 Heat Distribution Techniques

2.4.1 Radiant

OBJECTIVES	STRATEGIES
2.4.1.1 Define radiative heat transfer and explain why radiant heat "feels" so comfortable. 2.4.1.2 List three manufacturers of stoves which heat principally by radiation.	a. Lecture on radiative heat transfer explaining its meaning, how various heating appliances accomplish it, and why it feels so comfortable even below normal comfort-temperature ranges. b. Using various stove catalogs, have students classify stoves according to the heat distribution technique used.

NOTES:

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 10 mins.

2.4 Heat Distribution Techniques

2.4.2 Convection

OBJECTIVES	STRATEGIES
2.4.2.1 Define convection.	a. Lecture on convection.
2.4.2.2 Explain how convection is an aspect of all heat distribution techniques in the home.	b. Explain how heated air, when rising, establishes convective movement of air.

NOTES:

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 15 mins.

2.4 Heat Distribution Techniques

2.4.3 Circulation-Forced Air

OBJECTIVES	STRATEGIES
2.4.3.1 Understand that heated air rises, cools and falls in circulation patterns. 2.4.3.2 Diagram and label the parts of solid fuel forced air circulating stove. 2.4.3.3 Explain in writing how active circulation (as with a blower) increases heating efficiency by increasing the net flow of heat from the heating appliance to the living space.	a. Differentiate, by lecture, how convection is the upward movement of heated air but how circulated air rises and falls. b. Show pictures or diagrams of circulating appliances or special accessories that promote circulation. c. Use a hair dryer fan to blow 1000 watts of heat energy toward the class and discuss the slower rate of heat movement (and reduced heating efficiency) if the air circulation feature were not included in the dryer.*

NOTES:

*Use adequate safety precautions.

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 20 mins.

2.4 Heat Distribution Techniques

2.4.4 Circulation-Hydronic

OBJECTIVES	STRATEGIES
2.4.4.1 Explain how hydronic heating is a combination of all the other heat distribution techniques.	a. Use a tea kettle of hot water to demonstrate how hydronic heating really encompasses all heat distribution techniques.
2.4.4.2 Diagram and label a simple single loop hydronic heating system.	b. Show a diagram of a basic base-board hot water system hooked up to a heating appliance. Discuss the relative complexity of the system even if a convective-heat circulation system rather than a circulating pump is selected.*

NOTES:

*A number of multi-fuel furnaces use water for the heat transfer medium.

MAJOR CONCEPT 2.0 SOLID FUEL HEATING APPLIANCE DESIGN **TIME** 30 mins.

2.5 Location and Sizing

OBJECTIVES	STRATEGIES
2.5.1 Estimate the maximum wintertime B.T.U./hr requirement for an average home (16,000 cu. ft. of living space) and relate this to heating appliances on the market.	a. Invite a stove installer, consultant or other experienced specialist on sizing and location of stoves to speak to the class.
2.5.2 Using floor plans of a rancher and a two story colonial home, select and defend the selection of ideal and inferior locations for a fireplace, circulating/radiative airtight stove and a hydronic heating unit.	b. Show, on floor plans of one and two-story homes, how heating applicance location is dictated by room layout, type of appliance, type of chimney, etc., and show where an ideal placement would be.

NOTES:

This topic has an extremely large number of variables and probably can only be superficially covered.

CONCEPT 3.0

CHIMNEYS AND FLUES

MAJOR CONCEPT 3.0 - CHIMNEYS AND FLUES

EDUCATIONAL OBJECTIVES

The following objectives provide the teacher with an overview of the concepts and skills contained in this section.

The student will be able to:

3.1.1.1 sketch a sectional view of three types of all-fuel metal chimney pipes.

3.1.1.2 list circumstances where it is permissible to use single, double, or triple wall pipe as part of a chimney installation.

3.1.2.1 name the major components of a masonry chimney.

3.2.1.1 list the advantages of all-fuel metal chimney pipe and chimneys.

3.2.1.2 list the relative safety of each chimney type including recommended clearances from combustible surfaces.

3.2.2.1 write two disadvantages each of all-fuel metal chimney pipe and masonry chimneys.

3.3.1.1 define draft.

3.3.1.2 identify the properties of a chimney which promote adequate draft.

3.3.1.3 realize that various draft inducers are available commercially.

3.3.2.1 recognize the sources which provide information on correct flue liner size and other dimensional information.

3.4.1.1 identify aesthetic errors in chimney installations from a slide presentation.

3.4.2.1 select the best location for a flue in order to ensure adequate draft, fire protection, structural strength and aesthetics in the house.

3.4.3.1 explain standard construction of a masonry chimney with a clay flue liner, including building materials needed.

3.4.3.2 list the tools and skills required for construction of a masonry chimney with a flue liner.

3.4.4.1 explain the step-by-step procedure required for installation of an all-fuel metal chimney in a one-story and a two-story home.

3.4.4.2 identify six common all-fuel metal chimney components and define the function of each.

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 15 mins.

3.1 Types

3.1.1 Metal

OBJECTIVES	STRATEGIES
3.1.1.1 Sketch a sectional view of three types of all-fuel metal chimney pipes.	a. Place literature from all-fuel metal chimney suppliers on the bulletin board and discuss in class.
3.1.1.2 List circumstances where it is permissible to use single, double, or triple wall pipe as part of a chimney installation.	b. Show the construction of an all-fuel metal chimney by using a cutaway section. Explain reasons for the design. Transparency #8.
	c. Show double and triple wall all-fuel metal chimney pipe (without solid insulator) and explain why they are generally not recommended for solid fuels appliances.

NOTES:

All-fuel metal chimneys are also referred to as solid fuel, factory built, or class "A" metal chimneys. Regardless of terminology chimney should have an approved or listed (UL) rating.

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 15 mins.

3.1 Types

3.1.2 Masonry

OBJECTIVES	STRATEGIES
3.1.2.1 Name the major components of a masonry chimney.	a. Use a cutaway model or drawing of a masonry chimney from footing to chimney cap. Transparency #9.

NOTES:

This will not include fireplace construction as part of the chimney.

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 10 mins.

3.2 Selection of the Proper Flue

3.2.1 Advantages of the Types

OBJECTIVES	STRATEGIES
3.2.1.1 List the advantages of all-fuel metal chimney pipe and masonry chimneys.	a. Lecture on the advantages of all-fuel metal chimney pipe and of masonry chimneys.
3.2.1.2 List the relative safety of each chimney type including recommended clearances from combustible surfaces.	b. Hand out diagrams of flue installations showing recommended clearances from a combustible surface. Transparency #10.

NOTES:

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 10 mins.

3.2 Selection of the Proper Flue

3.2.2 Disadvantages of Types

OBJECTIVES	STRATEGIES
3.2.2.1 Write two disadvantages each of all-fuel metal chimney pipe and masonry chimneys.	a. Lecture on the disadvantages of all-fuel metal chimney pipe and of masonry chimneys. Cover expense, installation costs, flexibility and aesthetics.

NOTES:

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 10 mins.

3.3 Principles of Operation

3.3.1 Draft

OBJECTIVES	STRATEGIES
3.3.1.1 Define draft.	a. Provide manufacturers' literature on devices to promote draft.
3.3.1.2 Identify the properties of a chimney which promote adequate draft.	b. Lecture on how surrounding structures, vegetation and topography can influence draft.
3.3.1.3 Realize that various draft inducers are available commercially.	c. Show and discuss a diagram which shows the recommended chimney height relative to nearby buildings. Transparency #11.
	d. Show and discuss literature from manufacturers of various draft enhancers.

NOTES:

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 10 mins.

3.3 Principles of Operation

3.3.2 Dimensions

OBJECTIVES	STRATEGIES
3.3.2.1 Recognize the sources which provide information on correct flue liner size and other dimensional information.	a. Lecture on sources which publish proper dimensions of chimneys and flues. b. Use a chart* or lecture on recommended chimney or flue dimensions for an average-sized fireplace and for an average-sized stove.

NOTES:

*NFPA, Using Coal and Wood Stoves Safely, 1978.

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 10 mins.

3.4 Techniques of Installation

3.4.1 Aesthetics

OBJECTIVES	STRATEGIES
3.4.1.1 Identify aesthetic errors in chimney installations from a slide presentation.	a. Through pictures or a slide presentation, discuss the aesthetics of various chimneys.

NOTES:

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 20 mins.

3.4 Techniques of Installation

3.4.2 Location

OBJECTIVES	STRATEGIES
3.4.2.1 Select the best location for a flue in order to ensure adequate draft, fire protection, structural strength and aesthetics in the house.	a. Use typical wall, floor, ceiling and roof models to show proper placement of flues with regard to the structural members of the house. b. Use floor plans for a one-story and a two-story home and discuss placement of a stove* and special considerations which must be given to the chimney type selected.

NOTES:

*A review of 2.5.

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 30 mins.

3.4 Techniques of Installation

3.4.3 Masonry Flues

OBJECTIVES	STRATEGIES
3.4.3.1 Explain standard construction of a masonry chimney with a clay flue liner, including building materials needed.	a. Provide for a hands-on experience constructing a chimney using chimney block and clay flue liner in class (omit the mortar).
3.4.3.2 List the tools and skills required for construction of a masonry chimney with a flue liner.	b. Use pictures or lecture on chimney footing, chimney wall ties, mortar use, brick veneer, fire box, and throat details.
	c. Show materials and tools needed for installation and construction.

NOTES:

*See Lloyd Benjamin "How to build a masonry chimney." Home Energy Digest/ Woodburning Quarterly. Fall, 1979. p. 98-108.

Also slide program on Chimney construction from Riteway Manufacturing Co.

MAJOR CONCEPT 3.0 CHIMNEYS AND FLUES **TIME** 30 mins.

3.4 Techniques of Installation

3.4.4 Metal Flues

OBJECTIVES	STRATEGIES
3.4.4.1 Explain the step-by-step procedure required for installation of an all-fuel metal chimney in a one-story and a two-story home. 3.4.4.2 Identify six common all-fuel metal chimney components and define the function of each.	a. Display various all-fuel metal chimney parts and ask students to identify them and state function of each. b. Display literature showing correct installation of all-fuel metal chimney pipe.* (Obtain in quantity from various manufacturing companies.) c. Contact manufacturer and request that representative speak to class regarding correct installation of all-fuel metal chimneys.*

NOTES:

*See most recent edition of Woodstove Fireplace and Equipment Directory for companies which manufacture all-fuel metal chimneys. Also local plumbing/heating stores generally stock various types of all-fuel metal chimneys.

CONCEPT 4.0

RULES AND REGULATIONS

MAJOR CONCEPT 4.0 - SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS

EDUCATIONAL OBJECTIVES

The following objectives provide the teacher with an overview of the concepts and skills contained in this section.

The student will be able to:

4.1.1.1 recognize that most manufacturers provide detailed instructions to ensure proper installation.

4.1.2.1 recognize that most manufacturers provide detailed instruction to ensure safe operation.

4.2.1.1 recognize that the municipal fire marshal, building inspector or other governmental representative might require a building permit prior to construction or installation, and a use permit prior to the use of a heating appliance.

4.3.1.1 explain the purview of Underwriter's Laboratory (UL) in testing and approving safe appliances.

4.3.1.2 explain the purview of BOCA and NFPA in recommending the safe installation and operation of appliances and accessories and realize that they serve the consumer and the community at large.

4.3.2.1 label on the appropriate work sheet, minimum clearances required for wall or ceiling (for an airtight stove, a circulating stove, an uninsulated metal chimney and an all-fuel metal chimney with (a) no fireproof protection and (b) metal-clad 1/4 inch asbestos shield positioned one inch from the flammable surface.

4.4.1.1 understand that most higher-efficiency solid fuel appliances, particularly wood burners, have low flue temperatures and creosote formation is a continuous problem.

4.4.1.2 recognize that flues must be periodically cleaned of creosote with a brush or other method.

4.4.1.3 realize that ignited creosote can burn extremely hot and rapidly, causing house fires or flue damage.

4.4.2.1 list the more common structural faults which can be expected in masonry, steel and cast iron.

4.4.2.2 recognize where to inspect for structural faults and in general how to correct them.

5.4.1 know that solid fuel heating systems may be more hazardous than other modern home heating appliances if not properly maintained.

4.5.2 list two reasons why the home owner should inform the insurance company regarding the installation of a solid fuel heating system.

MAJOR CONCEPT 4.0 SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS **TIME** 15 mins.

4.1 Manufacturers' Recommendations

4.1.1 Installation

OBJECTIVES	STRATEGIES
4.1.1.1 Recognize that most manufacturers provide detailed instructions to ensure proper installation.	a. Highlight the installation recommendations* for two different appliances (e.g. radiant and circulating airtight stoves) for the class and discuss them.

NOTES:

*Available from manufacturer. See Woodstove, Fireplace and Equipment Directory, 1980.

MAJOR CONCEPT 4.0 SAFETY RECOMMENDATION, REGULATIONS, CODES AND LAWS **TIME** 15 mins.

4.1 Manufacturers' Recommendations

4.1.2 Operation

OBJECTIVES	STRATEGIES
4.1.2.1 Recognize that most manufacturers provide detailed instruction to ensure safe operation.	a. Highlight (for the class) instructions* for operating two different appliances (e.g. radiant and circulating airtight stoves) and discuss them.

NOTES:

*Available from manufacturers. See Woodstove, Fireplace and Equipment Directory, 1980.

MAJOR CONCEPT 4.0 SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS **TIME** 10 mins.

4.2 Municipal Building Codes

4.2.1 Obtaining Pertinent Installation/Use Permits

OBJECTIVES	STRATEGIES
4.2.1.1 Recognize that the municipal fire marshal, building inspector or other governmental representative might require a building permit prior to construction or installation, and a use permit prior to the use of a heating appliance.	a. Invite the municipal permits clerk to address the class about this requirement. b. Show the class a building permit and a use permit and explain the procedure and requirements for obtaining them.

NOTES:

MAJOR CONCEPT 4.0 SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS **TIME** 10 mins.

4.3 National Standards

4.3.1 Agencies and Organizations: UL, BOCA and NFPA

OBJECTIVES	STRATEGIES
4.3.1.1 Explain the purview of Underwriter's Laboratory (UL) in testing and approving safe appliances.	a. Lecture on the role of UL, BOCA, and NFPA in testing and formulating safe appliances, installations and operation. See bibliography for mailing addresses of the above organizations.
4.3.1.2 Explain the purview of BOCA and NFPA in recommending the safe installation and operation of appliances and accessories and realize that they serve the consumer and the community at large.	

NOTES:

MAJOR CONCEPT 4.0 SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS **TIME** 20 mins.

4.3 National Standards

4.3.2 Regulations for Safe Appliance Installation: Clearances

OBJECTIVES	STRATEGIES
4.3.2.1 Label on the appropriate work sheet, minimum clearances required for wall or ceiling (for an airtight stove, a circulating stove, an uninsulated metal chimney and an all-fuel metal chimney with (a) no fireproof protection and (b) metal-clad 1/4 inch asbestos shield positioned one inch from the flammable surface.	a. Hand out a chart listing NFPA regulations and minimum permissible clearances for solid fuel systems. b. Illustrated lecture on appropriate clearances. Transparency #12.

NOTES:

MAJOR CONCEPT 4.0 SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS **TIME** 10 mins.

4.4 Preventative Maintenance

4.4.1 Chimney Fires

OBJECTIVES	STRATEGIES
4.4.1.1 Understand that most higher-efficiency solid fuel appliances, particularly wood burners, have low flue temperatures and creosote formation is a continuous problem.	a. Lecture on the relationship of stove efficiency, flue temperature and creosote formation. Transparency #13.
4.4.1.2 Recognize that flues must be periodically cleaned of creosote with a brush or other method.	b. Lecture on the necessity of removing creosote periodically from the flue.
4.4.1.3 Realize that ignited creosote can burn extremely hot and rapidly, causing house fires or flue damage.	c. Lecture on how a fire can damage the flue or burn down a house.
	d. Ignite* with a propane torch, a heavily creosoted flue pipe provided with unlimited draft.

NOTES:

*Conduct this demonstration outside during a calm day on a non-flammable surface (not asphalt or tar, preferably concrete, cleared earth or gravel). The flames will leap high, probably dark smoke will be produced and some creosote will probably liquify and drip, burning, to the ground. Confer with the local fire marshal first on the advisability of this demonstration.

MAJOR CONCEPT 4.0 SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS **TIME** 10 mins.

4.4 Preventative Maintenance

4.4.2 Appliance Faults

OBJECTIVES	STRATEGIES
4.4.2.1 List the more common structural faults which can be expected in masonry, steel and cast iron. 4.4.2.2 Recognize where to inspect for structural faults and in general how to correct them.	a. Show samples of (a) unprotected cinder block that has weathered and degenerated, (b) metal surfaces which are oxidized, cracked and distorted due to heat and (c) firebrick that has broken down due to abrasion of fuel and intense heat. b. Explain through lectures and slides, how masonry chimneys can settle and crack. Point out where to look for the first signs of structural breakdown throughout the system and briefly how to repair the faults or what specialists could be called upon to correct the faults.

NOTES:

See J. Shelton, Wood Heat Safety, 1979, pp. 17-20.

MAJOR CONCEPT 4.0 SAFETY RECOMMENDATIONS, REGULATIONS, CODES AND LAWS **TIME** 10 mins.

4.5 Fire Insurance Implications

OBJECTIVES		STRATEGIES
4.5.1	Know that solid fuel heating systems may be more hazardous than other modern home heating appliances if not properly maintained.	a. Lecture on the incidence of house fires among houses with solid fuel heating systems. Transparency #14. b. Discuss the general manner by which insurance companies assign risks to subscribers and how they determine premium increases. c. Invite a specialist in fire underwriting from an insurance company to address this topic.
4.5.2	List two reasons why the home owner should inform the insurance company regarding the installation of a solid fuel heating system.	

NOTES:

CONCEPT 5.0

INSTALLATION

MAJOR CONCEPT 5.0 - INSTALLATION OF SOLID FUEL APPLIANCES

EDUCATIONAL OBJECTIVES

The followng objectives provide the teacher with an overview of the concepts and skills contained in this section.

The student will be able to:

5.1.1.1 understand that carpentry specialities are basically separated into the categories of rough carpentry (framing, sheathing, etc.) and trim carpentry (finishing details).

5.1.1.2 recognize that specialists in carpentry are required for installation of heating appliances.

5.1.2.1 understand that masonry specialities include 1) concrete placement and finishing, 2) block work and, 3) veneer application of bricks, stone, etc.

5.1.2.2 explain how foundations are placed, how blocks are laid and how a simple bond pattern of bricks is laid.

5.1.2.3 recognize that correct concrete and mortar mixtures are essential for their respective applications.

5.1.3.1 recognize that metal specialities required for solid fuel appliance installation are primarily sheet metal specialities.

5.2.1.1 list ten hand tools required for stove installation.

5.2.1.2 identify and understand the correct and safe use of hand tools.

5.2.2.1 list four portable power tools useful in stove installation and note the hand tools and operations they replace.

5.2.2.2 list the safety precautions for four portable power tools.

5.3.1.1 identify masonry and mineral-based fireproof products.

5.3.1.2 identify three commercial metal fireproof products.

5.3.1.3 explain the degree to which fireproof materials can conduct heat through themselves to combustive structures.

5.3.2.1 - list three fire resistant/retardant materials in commercial use.

5.3.2.2 explain the difference between fireproof and fire resistant.

5.3.3.1 list flammable materials common in the home.

5.3.3.2 define differences between charring, smoldering and burning.

5.4.1.1 sketch the basic construction details of a fireplace from the foundation to the top of the chimney.

5.4.2.1 sketch warm air flow of a typical masonry fireplace containing a heat circulating metal insert.

5.4.3.1 outline the specific steps in installing a metal stove including: 1) wall and floor fire protection, 2) flue pipe fire protection and 3) permissible clearances.

5.4.4.1 outline the variety of plumbing/heating/electrical tasks which installation of multi-fuel systems require.

5.4.4.2 sketch the flow of heat from either a forced air or hydronic heating system.

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 10 mins

5.1 Skills Required

5.1.1 Carpentry

OBJECTIVES	STRATEGIES
5.1.1.1 Understand that carpentry specialities are basically separated into the categories of rough carpentry (framing, sheathing, etc.) and trim carpentry (finishing details)	a. Discuss the carpentry skills required to install a wood stove near a combustible surface using an all-fuel and masonry chimney.
5.1.1.2 Recognize that specialists in carpentry are required for installation of heating appliances.	

NOTES:

*See K. Kern and S. Magers, Fireplaces.
Also, J. Shelton, Wood Heat Safety.

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 15 mins.

5.1 Skills Required

5.1.2 Masonry

OBJECTIVES	STRATEGIES
5.1.2.1 Understand that masonry specialities include 1) concrete placement and finishing, 2) block work and 3) veneer application of bricks, stone, etc.	a. By lecture and demonstration, point out basic masonry specialties and masonry techniques.
5.1.2.2 Explain how foundations are placed, how blocks are laid and how a simple bond pattern of bricks is laid.	b. Use hand-outs which diagram how foundations are placed and how blocks and bricks are laid.*
5.1.2.3 Recognize that correct concrete and mortar mixtures are essential for their respective applications.	c. Briefly discuss several simple brick bonds.
	d. Lecture on the correct mixtures of concrete and mortar used for foundations and for brick and block work.
	e. Discuss structural faults which can be expected if weak mortar mixtures are used.
	f. Prepare correct and incorrect mortar mixtures and test their strength and durability in class.

NOTES:

J.R. Dalzell and Gilbert Townsend, Masonry Simplified, 1970.
*See also, Masonry Chimney Construction, 35 mm slide program Riteway Corp.

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 10 mins.

5.1 Skills Required

5.1.3 Metalworking

OBJECTIVES	STRATEGIES
5.1.3.1 Recognize that metal specialties required for solid fuel appliance installation are primarily sheet metal specialities.	a. Use lecture to describe the sheet metal operations related to stove installation. b. Reinforce through discussion that sheet metal specialties are heavily involved in heating installation.

NOTES:

Reference: R.S. Budzik, Sheet Metal Technology, 1975.

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 10 mins.

5.2 Tools Required

5.2.1 Hand Tools

OBJECTIVES	STRATEGIES
5.2.1.1 List ten hand tools required for stove installation. 5.2.1.2 Identify and understand the correct and safe use of hand tools.	a. Display various hand tools and discuss their safe usage.

NOTES:

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 10 mins.

5.2 Tools Required

5.2.2 Power Tools

OBJECTIVES	STRATEGIES
5.2.2.1 List four portable power tools useful in stove installation and note the hand tools and operations they replace. 5.2.2.2 List the safety precautions for four portable power tools	a. Display and demonstrate time and effort saved by using portable power tools. b. Discuss safe usage of power tools.

NOTES:

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 15 mins.

5.3 Materials

5.3.1 Fireproof Materials

OBJECTIVES	STRATEGIES
5.3.1.1 Identify masonry and mineral-based fireproof products. 5.3.1.2 Identify three commercial metal fireproof products. 5.3.1.3 Explain the degree to which fireproof materials can conduct heat through themselves to combustible structures.	a. Show samples or pictures of masonry and mineral-based commercial fireproof products and discuss advantages and disadvantages of each. b. Show samples or pictures of commercial metal fireproof products and devices. c. Lecture on insulation and conduction of heat. Using a propane torch and thermometer, conduct experiments on heat insulation or conduction by various fireproof materials.*

NOTES:

*Use adequate safety precautions for this demonstration.

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 15 mins.

5.3 Materials

5.3.2 Fire Resistant/Retardant Materials

OBJECTIVES	STRATEGIES
5.3.2.1 List three fire resistant/retardant materials in commercial use. 5.3.2.2 Explain the difference between fireproof and fire resistant.	a. Show and discuss commercial fire resistant/retardant materials. b. With a propane torch, show the limitations of fire protection in several fire resistant/retardant items.*

NOTES:

*Use adequate safety precautions for this demonstration.

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 15 mins.

5.3 Materials

5.3.3 Flammable Materials

OBJECTIVES	STRATEGIES
5.3.3.1 List flammable materials common in the home. 5.3.3.2 Define differences between charring, smoldering and burning.	a. With a torch, ignite small pieces of wood, a nylon shag/foam padded carpet, and vinyl tile.* b. Lecture on charring and reduction of flash point in dry vs. wet wood.**

NOTES:

*Use adequate safety precautions.

**See J. Shelton and A. Shapiro, The Woodburners Encyclopedia, p. 70 & p. 99, 1976.

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 30 mins.

5.4 Procedure

5.4.1 Fireplace

OBJECTIVES	STRATEGIES
5.4.1.1 Sketch the basic construction details of a fireplace from the foundation to the top of the chimney.	a. Illustrate how a simple fireplace is installed. Transparency #9.

NOTES:

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 35 mins.

5.4 Procedure

5.4.2 Fireplace with Heat Circulator

OBJECTIVES	STRATEGIES
5.4.2.1 Sketch warm air flow of a typical masonry fireplace containing a heat circulating metal insert.	a. Illustrated lecture on various types of heat circulating fireplaces. Transparency #15. b. Obtain literature from manufacturing companies who produce heat circulating metal inserts.

NOTES:

See also K. Kern,and S. Magers. Fireplaces, 1979, pgs. 111-142.

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 45 mins.

5.4 Procedure

5.4.3 Metal Stove on or Near Combustible Surface.

OBJECTIVES	STRATEGIES
5.4.3.1 Outline the specific steps in installing a metal stove including: 1) wall and floor fire protection, 2) flue pipe fire protection and 3) permissible clearances.	a. Discuss installation of an air-tight stove (review safety clearances, chimney installation). Transparency #12. b. Show and discuss pictures of correctly and incorrectly installed stoves.

NOTES:

MAJOR CONCEPT 5.0 INSTALLATION OF SOLID FUEL APPLIANCES **TIME** 45 mins.

5.4 Procedure

5.4.4 Multi-Fuel Systems

OBJECTIVES	STRATEGIES
5.4.4.1 Outline the variety of plumbing/heating/electrical tasks which installation of multi-fuel systems require.	a. By pictures or demonstration, cover the plumbing, heating and electrical requirements of multi-fuel furnaces.
5.4.4.2 Sketch the flow of heat from either a forced air or hydronic heating system.	b. Using manufacturers literature, illustrate heat transfer typical of forced air and hydronic multi-fuel furnaces.*

NOTES:

*See V.D. Chase, "Multi-Fuel Furnaces" in Popular Science for addresses of manufacturing companies.

CONCEPT 6.0

MAINTENANCE

MAJOR CONCEPT 6.0 - MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM

EDUCATIONAL OBJECTIVES

The following objectives provide the teacher with an overview of the concepts and skills contained in this section.

The student will be able to:

6.1.1.1 explain why a period of hot burning of fuel daily in an appliance reduces creosote build-up.

6.1.1.2 explain the function of an ashbed in a heating appliance and explain when removal is necessary.

6.1.1.3 list the important periodic maintenance measures required of solid fuel heating systems.

6.1.2.1 recognize that regular maintenance can reduce the likelihood of expensive and untimely appliance shutdowns and replacements.

6.2.1.1 list the types of chimneys/flues, ranking them by their durability.

6.2.2.1 list two ways old chimneys can be inspected for safety.

6.2.2.2 explain what fire hazards can exist in old chimneys.

6.2.3.1 outline the tools required and techniques used for cleaning flues.

6.2.3.2 list health and home-cleanliness precautions required when cleaning a chimney.

6.3.2.1 realize that open fireplaces require large volumes of air for combustion, while air-tight stoves require much less air.

6.3.2.2 understand that outside air infiltration, in effect, reduces a heating appliance's efficiency.

6.3.2.3 list areas of the home where outside air infiltration poses most problems and reveal how to solve them.

6.3.3.1 define R-value.

6.3.3.2 list the major types of home insulation and their relative R-values.

6.3.3.3 explain why adequate ceiling insulation is more important for heat retention than wall or floor insulation.

6.3.3.4 explain how proper insulation means more effective heating from an appliance.

6.3.3.5 list the recommended R-values of insulation for various parts of a typical home.

6.3.1.1 sketch the basic pattern of heat circulation in a cube-shaped room with a heating appliance against one wall.

6.3.1.2 explain two methods which can direct heat in a particular direction.

MAJOR CONCEPT 6.0 MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM **TIME** 30 mins.

6.1 Wise Appliance Operation

6.1.1 Daily Through Yearly Maintenance

OBJECTIVES	STRATEGIES
6.1.1.1 Explain why a period of hot burning of fuel daily in an appliance reduces creosote build-up.	a. Explain the effect of high temperatures on fresh, tacky creosote--demonstrate, if possible.*
6.1.1.2 Explain the function of an ashbed in a heating appliance and explain when removal is necessary.	b. Discuss the function of an ashbed in a heating appliance, especially coal burning stoves.
6.1.1.3 List the important periodic maintenance measures required of solid fuel heating systems	c. Using schematics and pictures of the basic types of heating appliances, point out the recommended periodic maintenance needs.

NOTES:

*See J.W. Shelton, Wood Heat Safety, pp. 78-80.

MAJOR CONCEPT 6.0 MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM **TIME** 30 mins.

6.1 Wise Appliance Operation

6.1.2 Preventative Maintenance

OBJECTIVES	STRATEGIES
6.1.2.1 Recognize that regular maintenance can reduce the likelihood of expensive and untimely appliance shutdowns and replacements.	a. Using pictures and diagrams of heating appliances, review their vulnerable features and explain how preventative maintenance can extend their utility.

NOTES:

MAJOR CONCEPT 6.0 MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM **TIME** 30 mins.

6.2 Maintaining the Chimney and Flue

6.2.1 Durability of Types

OBJECTIVES	STRATEGIES
6.2.1.1 List the types of chimneys/ flues, ranking them by their durability.	a. Discuss durability of chimneys/ flues. b. Demonstrate how stainless steel is superior to black iron stove pipe by wetting them (rust vulnerability) and subjecting them to a dilute acid.* c. Demonstrate the resistance of fire clay flue liner to all weathering except shattering.

NOTES:

*Can cause severe burns to eyes and to skin. Use adequate safety precautions.

MAJOR CONCEPT 6.0 MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM **TIME** 15 mins.

6.2 Maintaining the Chimney and Flue

6.2.2 Inspecting Old Chimneys

OBJECTIVES	STRATEGIES
6.2.2.1 List two ways old chimneys can be inspected for safety.	a. Discuss how and why old chimneys should be examined.
6.2.2.2 Explain what fire hazards can exist in old chimneys.	b. Discuss the fire hazards which can exist in old chimneys.

NOTES:

MAJOR CONCEPT 6.0 MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM **TIME** 30 mins.

6.2 Maintaining the Chimney and Flue

6.2.3 Cleaning Techniques

OBJECTIVES	STRATEGIES
6.2.3.1 Outline the tools required and techniques used for cleaning flues.	a. Invite a chimney sweep to speak to the class about chimney cleaning.
6.2.3.2 List health and home-cleanliness precautions required when cleaning a chimney.	b. Show chimney cleaning equipment and discuss the techniques for cleaning.

NOTES:

See E. Horton. The Chimney Brush, 1977.

MAJOR CONCEPT 6.0 MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM **TIME** 20 mins.

6.3 Keeping Heat Inside the House

6.3.1 Heat Distribution

OBJECTIVES	STRATEGIES
6.3.1.1 Sketch the basic pattern of heat circulation in a cube-shaped room with a heating appliance against one wall.	a. Show a diagram explaining the thermodynamics of heated/cooled air movements. Introduce heated smoke into a model room to show movements of air.
6.3.1.2 Explain two methods which can direct heat in a particular direction.	b. Discuss methods, such as blowers, ceiling vents and wall vents, which direct heat to a particular location. Transparency #16.

NOTES:

MAJOR CONCEPT 6.0 MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM **TIME** 20 mins.

6.3 Keeping Heat Inside the House

6.3.2 Outside Air Infiltration

OBJECTIVES	STRATEGIES
6.3.2.1 Realize that open fireplaces require large volumes of air for combustion, while air-tight stoves require much less air.	a. Discuss combustion air requirements of heating appliances and options for providing it.*
6.3.2.2 Understand that outside air infiltration, in effect, reduces a heating appliance's efficiency.	b. Compute the amount of area open to the outside in a typical home without adequate caulking and weather stripping.
6.3.2.3 List areas of the home where outside air infiltration poses most problems and reveal how to solve them.	

NOTES:

*See J. Shelton and A. Shapiro, Woodburners Encyclopedia, p. 68.

MAJOR CONCEPT 6.0 MANAGEMENT & MAINTENANCE OF THE HEATING SYSTEM **TIME** 20 mins.

6.3 Keeping Heat Inside the House

6.3.3 Insulation

OBJECTIVES	STRATEGIES
6.3.3.1 Define R-value.	a. Using a diagram, show and discuss the recommended R-values of insulation which a typical home should have.
6.3.3.2 List the major types of home insulation and their relative R-values.	b. Use a chart listing R-values of the common types of home insulation.*
6.3.3.3 Explain why adequate ceiling insulation is more important for heat retention than wall or floor insulation.	
6.3.3.4 Explain how proper insulation means more effective heating from an appliance.	
6.3.3.5 List the recommended R-values of insulation for various parts of a typical home.	

NOTES:

*See transparency masters from Project Retrotech--Home Weatherization Charts, 1979.

CONCEPT 7.0

OCCUPATIONS

MAJOR CONCEPT 7.0 - OCCUPATIONS

EDUCATIONAL OBJECTIVES

The following objectives provide the teacher with an overview of the concepts and skills contained in this section.

The student will be able to:

7.1.1.1 name occupations of five trades people active in home solid fuel appliance installation and describe their specific functions.

7.1.1.2 discuss training and formal education required for each skill.

7.1.2.1 name occupations of five speciality installers active in home solid fuel appliance installation and reveal their specific functions.

7.1.2.2 discuss training and formal education required for each skill.

7.2.1.1 name occupations of five maintenance people active in home solid fuel appliance maintenance and discuss their specific functions.

7.2.1.2 discuss training and formal education required for each skill.

7.3.1.1 list three business establishments which would employ salespeople for construction materials.

7.3.2.1 list three business establishments which would employ salespeople for burning appliances and flue materials.

7.3.3.1 list three business establishments which would employ salespeople for replacement equipment.

7.3.4.1 list three business establishments which would employ salespeople for maintenance equipment and supplies.

7.3.5.1 list three business establishments which would employ salespeople for fuels.

7.4.1.1 explain why regulatory and monitor personnel are required both at the manufacturer's and the consumer's level.

7.4.1.2 list the duties of a typical regulatory or monitor specialist.

7.4.1.3 reveal the kind of training or education required for these occupations.

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 15 mins.

7.1 Installation

7.1.1 Trades People

OBJECTIVES	STRATEGIES
7.1.1.1 Name occupations of five trades people active in home solid fuel appliance installation and describe their specific functions. 7.1.1.2 Discuss training and formal education required for each skill.	a. Review skills required for installation of solid fuel appliance (see section 5.0) and training or education required. b. Contact local solid fuel stove dealer and ask proprietor to discuss with class the skills needed for stove installation.

NOTES:

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 15 mins.

7.1 Installation

7.1.2 Specialty Installer

OBJECTIVES	STRATEGIES
7.1.2.1 Name occupations of five specialty installers active in home solid fuel appliance installation and reveal their specific functions. 7.1.2.2 Discuss training and formal education required for each skill.	a. Working with installation instruction materials from stove and chimney manufacturers, point out the important specialty skills related to home heating with solid fuels.

NOTES:

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 15 mins.

7.2 Maintenance

7.2.1 Trades People

OBJECTIVES	STRATEGIES
7.2.1.1 Name occupations of five maintenance people active in home solid fuel appliance maintenance and discuss their specific functions.	a. Review skills required for maintenance (see section 5.0) of solid fuel appliances and training or education required.
7.2.1.2 Discuss training and formal education required for each skill.	

NOTES:

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 10 mins.

7.3 Sales

7.3.1 Construction Materials

OBJECTIVES	STRATEGIES
7.3.1.1 List three business establishments which would employ sales people for construction materials.	a. Discuss local, regional and national outlets for supplies and equipment. b. Discuss the kind of training or education a salesperson would be required to have. c. Invite a salesperson to talk to the class about his/her occupation.

NOTES:

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 10 mins.

7.3 Sales

7.3.2 Burning Appliances, Flues

OBJECTIVES	STRATEGIES
7.3.2.1 List three business establishments which would employ salespeople for burning appliances and flue materials.	a. Discuss local, regional and national outlets for supplies and equipment. b. Discuss the kind of training or education a salesperson would be required to have. c. Invite a salesperson to talk to the class about his/her occupation.

NOTES:

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 15 mins.

7.3 Sales

7.3.3 Replacement Equipment

OBJECTIVES	STRATEGIES
7.3.3.1 List three business establishments which would employ salespeople for replacement equipment.	a. Discuss local, regional and national outlets for supplies and equipment. b. Discuss the kind of training or education a salesperson would be required to have. c. Invite a salesperson to talk to the class about his/her profession.

NOTES:

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 10 mins.

7.3 Sales

7.3.4 Maintenance Equipment and Supplies

OBJECTIVES	STRATEGIES
7.3.4.1 List three business establishments which would employ salespeople for maintenance equipment and supplies.	a. Discuss local, regional and national outlets for supplies and equipment. b. Discuss the kind of training or education a salesperson would be required to have. c. Invite a salesperson to talk to the class about his/her occupation.

NOTES:

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 15 mins.

7.3 Sales

7.3.5 Fuels

OBJECTIVES	STRATEGIES
7.3.5.1 List three business establishments which would employ salespeople for fuels.	a. Discuss local, regional and national outlets for supplies and equipment. b. Discuss the kind of training or education a salesperson would be required to have. c. Invite a salesperson to talk to the class about his/her occupation.

NOTES:

MAJOR CONCEPT 7.0 OCCUPATIONS **TIME** 45 mins.

7.4 Regulatory and Monitor Personnel

7.4.1 Local Through Federal

OBJECTIVES	STRATEGIES
7.4.1.1 Explain why regulatory and monitor personnel are required both at the manufacturer's and the consumer's level.	a. Discuss why regulatory and monitoring personnel are required both at the manufacturer's and consumer's level.
7.4.1.2 List the duties of a typical regulatory or monitor specialist.	b. Select one or two representative regulatory or monitor specialists and reveal his/her: a) typical training and education, and b) duties on the job.
7.4.1.3 Reveal the kind of training or education required for these occupations.	c. Write to UL, NFPA and BOCA for literature describing methods used to rate and monitor solid fuel burning appliances. (See Bibliography for addresses).

NOTES:

CONCEPT 8.0

ENVIRONMENTAL CONSIDERATIONS

MAJOR CONCEPT 8.0 - ENVIRONMENTAL CONSIDERATIONS

EDUCATIONAL OBJECTIVES

The following objectives provide the teacher with an overview of the concepts and skills contained in this section.

The student will be able to:

8.1.1.1 identify common local hardwood trees by their growth form, leaves and/or bark.

8.1.1.2 rank dried firewood from common trees in order of relative heat output.

8.1.2.1 map "cull trees" useful for firewood in a forest.

8.1.2.2 measure the firewood yield of a large tree.

8.1.2.3 select the best planting method and kinds of trees for a reforestation project.

8.2.1.1 diagram the geologic conditions of coal distribution in deep shaft mining areas and in the strip mining areas.

8.2.1.2 discuss five environmental and health problems associated with the coal mining industry.

8.3.1.1 measure flue pipe smoke pollution by using the Ringelman method.

8.3.1.2 list the health problems resulting from particulates associated with wood and coal smoke.

8.3.1.3 recognize the influence of particulates in causing plant damage and death.

8.3.21. comprehend that although carbon dioxide is a natural product of burning, it can have profound "pollution" impact.

8.3.2.2 diagram the fate of light and heat rays in a greenhouse and relate this to the greenhouse effect which is caused by the elevated atmospheric carbon dioxide concentration.

8.3.2.3 describe the effects that increased global temperature might have on weather, sea level, crops and human welfare in general.

8.3.3.1 list five very noxious gases of solid fuel combustion and explain how or why each is harmful to plants and animals.

8.3.4.1 measure the pH (acidity) of rainwater with test paper from temporally different samples of rain during a storm.

8.3.4.2 explain how acid rain can affect the economy and ecology of man.

8.3.5.1 handle unsorted coal ashes and measure or otherwise reveal how much ash results from a given initial amount of fuel.

8.3.5.2 project and predict pollutional problems of coal ash for a town with municipal garbage collection.

8.4.1.1 analyze how much rare liquid or gaseous fossil fuel is conserved when wood or coal is burned for home heating.

8.4.2.1 compare nutrients and alkalai (lime-like properties) of wood ashes with commercial fertilizer and ground limestone.

8.4.2.2 state the proper procedure for discarding coal ashes.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 10 mins.

8.1 Renewable Resources

8.1.1 Common Hardwood Trees*

OBJECTIVES	STRATEGIES
8.1.1.1 Identify common local hardwood trees* by their growth form, leaves and/or bark.	a. Conduct a field trip to a typical mature hardwood forest and point out species plus distinguishing characteristics.
8.1.1.2 Rank dried firewood from common trees in order of relative heat output.	b. Tour school grounds and nearby areas if desirable for the purpose of tree study.
	c. Project color slides or use pictures in class to teach tree form, leaves, etc.
	d. Use a diagram to show relative heat output of various firewoods. Transparency #17.

NOTES:

*Topic 1.0 dealt with wood and bark of softwoods and hardwoods. A combination of the two might be preferable to some teachers rather than this division. Also for tree identification see H. Zim and M. Morton, Trees, 1961.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 10 mins.

8.1 Renewable Resources

8.1.2 Woodlot Management

OBJECTIVES	STRATEGIES
8.1.2.1 Map "cull trees" useful for firewood in a forest.	a. Conduct a field trip to a typical mature hardwood forest* and point out culls.
8.1.2.2 Measure the firewood yield of a large tree.	b. Project color slides or use photographs to teach about cull tree recognition. Transparency #18.
8.1.2.3 Select the best planting method and kinds of trees for a reforestation project.	c. Use line diagrams to convey why trees are considered to be culls.
	d. Explain how firewood yield is estimated.
	e. Work with a "hypothetical" tall-trunked forest oak and a short but multi-branched open grown oak for computation and comparison of cord wood yield.
	f. Invite a state forester, nursery speciaist, silva-culturalist or other forestry specialist to discuss wood lot management and reforestation in particular.
	g. Use information from Weyerhauser or other commercial timber harvesters about tree harvest and reforestation.

NOTES:

*This might best be combined with 8.1.1 field trip.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 10 mins.

8.2 Non-Renewable Resources

8.2.1 Environmental Impact of Coal Mining, Processing, etc.

OBJECTIVES	STRATEGIES
8.2.1.1 Diagram the geologic conditions of coal distribution* in deep shaft mining areas and in the strip mining areas.	a. Use soil strata maps of a representative Appalachian region and of a representative western coal reserve area.
8.2.1.2 Discuss five environmental and health problems associated with the coal mining industry.	b. Lecture/discuss the environmental and health problems associated with the coal mining industry.
	c. Use slides, pictures, newspaper and magazine articles about pollution/health problems due to coal.

NOTES:

*1.0 dealt with location of U.S. coal reserves.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 15 mins.

8.3 Pollution From Burning

8.3.1 Smoke Effects

OBJECTIVES	STRATEGIES
8.3.1.1 Measure flue pipe smoke pollution by using the Ringelman method.	a. Tour the community and use a Ringelman filter to assess smoke pollution*.
8.3.1.2 List the health problems resulting from particulates associated with wood and coal smoke.	b. Lecture on the health problems of particulates of smoke.
8.3.1.3 Recognize the influence of particulates in causing plant damage and death.	c. Point out the surgeon general's warning on cigarette packs and discuss the importance of "tars" in cigarettes and similar materials in coal and wood smoke to our health.
	d. Lecture on particulates and gases on plant vigor.
	e. Invite an inspector for air pollution from the state or federal government to speak to the class.

NOTES:

*This is of course best to do during the cold, heating season.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 30 mins.

8.3 Pollution from Burning

8.3.2 Carbon Dioxide and Greenhouse Effects

OBJECTIVES	STRATEGIES
8.3.2.1 Comprehend that although carbon dioxide is a natural product of burning, it can have profound "pollution" impact. 8.3.2.2 Diagram the fate of light and heat rays in a greenhouse and relate this to the greenhouse effect which is caused by the elevated atmospheric carbon dioxide concentration. 8.3.2.3 Describe the effects that increased global temperature might have on weather, sea level, crops and human welfare in general.	a. Guide students in construction of a desk-size polyethylene covered "greenhouse." It can be as simple as an inflated and sealed plastic bag. Place in sunlight with an enclosed thermometer and compare temperature inside and outside of the "greenhouse." b. Compare heat trapping (use a thermometer) in a "greenhouse" filled with atmospheric air and one into which a short burst of carbon dioxide from a fire extinguisher* has been introjected. Place in sunlight and use a thermometer. c. Lecture on the effects of increased global temperatures and human affairs.

NOTES:

*It is best to supply a separate carbon dioxide extinguisher rather than jeopardize the fire-fighting efficiency of the classroom extinguisher, which could result from a partial discharge of its contents.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 15 mins.

8.3 Pollution from Burning

8.3.3 Effects of Noxious Gases

OBJECTIVES	STRATEGIES
8.3.3.1 List five very noxious gases of solid fuel combustion and explain how or why each is harmful to plants and animals.	a. Lecture/discuss noxious gases resulting from burning solid fuels. Reveal their harmful effects.

NOTES:

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 15 mins.

8.3 Pollution From Burning

8.3.4 Acid Rain Effects

OBJECTIVES	STRATEGIES
8.3.4.1 Measure the pH (acidity) of rainwater with test paper* from temporally different samples of rain during a storm.	a. Use a rain gauge (or just a drinking glass) to catch rainwater and with test paper,* measure its pH.
8.3.4.2 Explain how acid rain can affect the economy and ecology of man.	b. During a prolonged storm, take rainwater samples early and late in the storm. Measure the pH.
	c. Lecture on acid rain effects.

NOTES:

*Use narrow acid range of about 2.0 to 6.0 pH.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 15 mins.

8.3 Pollution from Burning

8.3.5 Coal Ashes

OBJECTIVES	STRATEGIES
8.3.5.1 Handle unsorted coal ashes and measure or otherwise reveal how much ash results from a given initial amount of fuel.	a. Supply the spent ashes from a known quantity of coal.* Students should sift and separate it into fine ash, klinkers and unburned coal. Weigh** each category.
8.3.5.2 Project and predict pollutional problems of coal ash for a town with municipal garbage collection.	b. Through lecture and discussion, project pollutional impact of coal ashes for a town with municipal garbage collection.

NOTES:

*About 50 pounds of fresh fuel. Use adequate safety precautions.
**Some categories represent only a few ounces, while others will weigh several pounds.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 15 mins.

8.4 Conservation Aspects

8.4.1 Wood or Coal vs. Gas or Fuel Oil

OBJECTIVES	STRATEGIES
8.4.1.1 Analyze how much rare liquid or gaseous fossil fuel is conserved when wood or coal is burned for home heating.	a. Show a chart of heat energy in coal, wood, gas, and fuel oil and explain how to equate one fuel to the other. Transparency #19. b. Have students compute their home heating bills* for December through February. Relate fuel used to cubic feet of living space heated.** c. By comparisons in class, compute fossil fuel savings when alternate energy is used. Transparency #20.

NOTES:

*Should this not be possible or embarrassing, supply figures from your home.
**The room sizes, including ceiling heights will be required.

MAJOR CONCEPT 8.0 ENVIRONMENTAL CONSIDERATIONS **TIME** 15 mins.

8.4 Conservation Aspects

8.4.2 Uses for Wood Ashes and Coal Ashes

OBJECTIVES	STRATEGIES
8.4.2.1 Compare nutrients and alkalai (lime-like properties) of wood ashes with commercial fertilizer and ground limestone.	a. Use a soil test kit to test* for potassium, phosphorus and nitrogen in wood ash.
	b. Measure the pH* of wood ash and that of ground limestone with test paper.
8.4.2.2 State the proper procedure for discarding coal ashes.	c. Discuss the ease and problems of spreading wood ashes on farms and garden.
	d. Have groups of students determine how coal ashes should be discarded e.g. contact utility company, coal suppliers, etc.

NOTES:

*Mix 1 cup of ash or limestone with 2 cups of water. Stir and strain out the clear fluid through a towel. Test this fluid with soil test reagents or pH test paper. (Use wide range basic paper: pH 7 to 14.)

EVALUATION

EVALUATION OF COMPETENCIES

Time did not permit the development of an extensive evaluation plan for this instructional package. However, a chart for evaluating the very basic competencies that a student should acquire through instruction has been developed. The chart in the form of a profile can be used as a checklist to show the student's performance level in several basic competencies. The chart, which appears on the next page, lists the basic competencies in the left hand column. The columns on the right relate to the performance level obtained by the student for each competency. The teacher and/or the student can select the performance level for each competency using one of the following keys:

If the competency is a manipulative skill, one of the following numbered columns is checked:

0 = Unacceptable
1 = Introduced
2 = Requires Supervision
3 = Works Independently

If the competency is a cognitive skill (e.g. understanding information) one of the following numbered columns is checked:

0 = Unacceptable
1 = Average
2 = Above Average
3 = Superior

A variety of evaluation devices will need to be developed by the teacher to provide the information necessary for accurately completing the profile chart. These devices will vary with individual teachers, but will probably include written tests, manipulative performance tests, teacher observations and student self-evaluations to name a few.

Although the task of constructing these devices has been left up to the individual teacher, project staff felt that this task will be facilitated by referring to the educational objectives listed for each third level concept. The objectives have been written in behavioral terms and provide a definitive statement regarding what the student should know or be able to do. Written in this fashion, the objectives should provide the teacher with the primary information needed for the development of various evaluation instruments.

BASIC COMPETENCY PROFILE CHART
Heating with Solid Fuels

Competencies	Performance Level *	0	1	2	3
1. Identifying the most common solid fuels and indicating their availability.					
2. Comparing fuels by their burning characteristics.					
3. Listing methods for storing fuels and describing safety considerations for storage.					
4. Comparing solid fuel burning units with respect to design and burning characteristics.					
5. Identifying proper size and location for heating appliances.					
6. Identifying contributing factors to creosote build up and methods to correct creosote problems.					
7. Locating a stove and chimney for efficiency and aesthetics.					
8. Describing principles of chimney operation and installation.					
9. Naming the types of chimneys which can be used safely.					
10. Inspecting for proper stove/chimney clearances for preventative maintenance.					
11. Securing installation and use permits.					
12. Naming skills, tools and training required for installing solid fuel systems.					
13. Installing a simple stove, fire protection package and all fuel metal chimney.					
14. Listing the effects of flame and heat on a home and stove construction materials.					
15. Understanding the environmental significance of solid fuels for home heating.					
16. Comprehending the important health and environmental problems of air pollution.					
17. Listing the occupations associated with solid fuel space heating systems.					

*KEY:

If a Manipulative Skill, Check
- 0 = Unacceptable
- 1 = Introduced
- 2 = Requires Supervision
- 3 = Works Independently

If Information, Check
- 0 = Unacceptable
- 1 = Average
- 2 = Above Average
- 3 = Superior

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Chimney Construction available from Riteway Manufacturing Co., P.O. Box 153, Harrisonburg, Va. 22801 (color slides of masonry construction techniques.)

[1](G.I.) = "General information"; indicates reference book with a broad scope of information.

TRANSPARENCY MASTERS

TRANSPARENCY #1

TYPES OF COAL

1. Lignite - brown coal - splits into slabs when dry
2. Cannel - (fireplace coal) - dull lustre, homogenous small size
3. Bituminous - deep black - cubical orprismatic fracture
4. Anthracite - hard black, brittle - bright lustre with conchoidal fracture

	Anthracite	Bituminous
Sulfur	1/2%	3-4%
Fixed Carbon	87%	69%
Volatile Matter	4%	31%
Ash	8-10%	Unknown
Dust	less	more
Visible Smoke	less	more
Availability	less abundant	most abundant

TRANSPARENCY #2

AMOUNT OF OTHER FUELS EQUIVALENT TO A CORD OF AIR-DRY WOOD

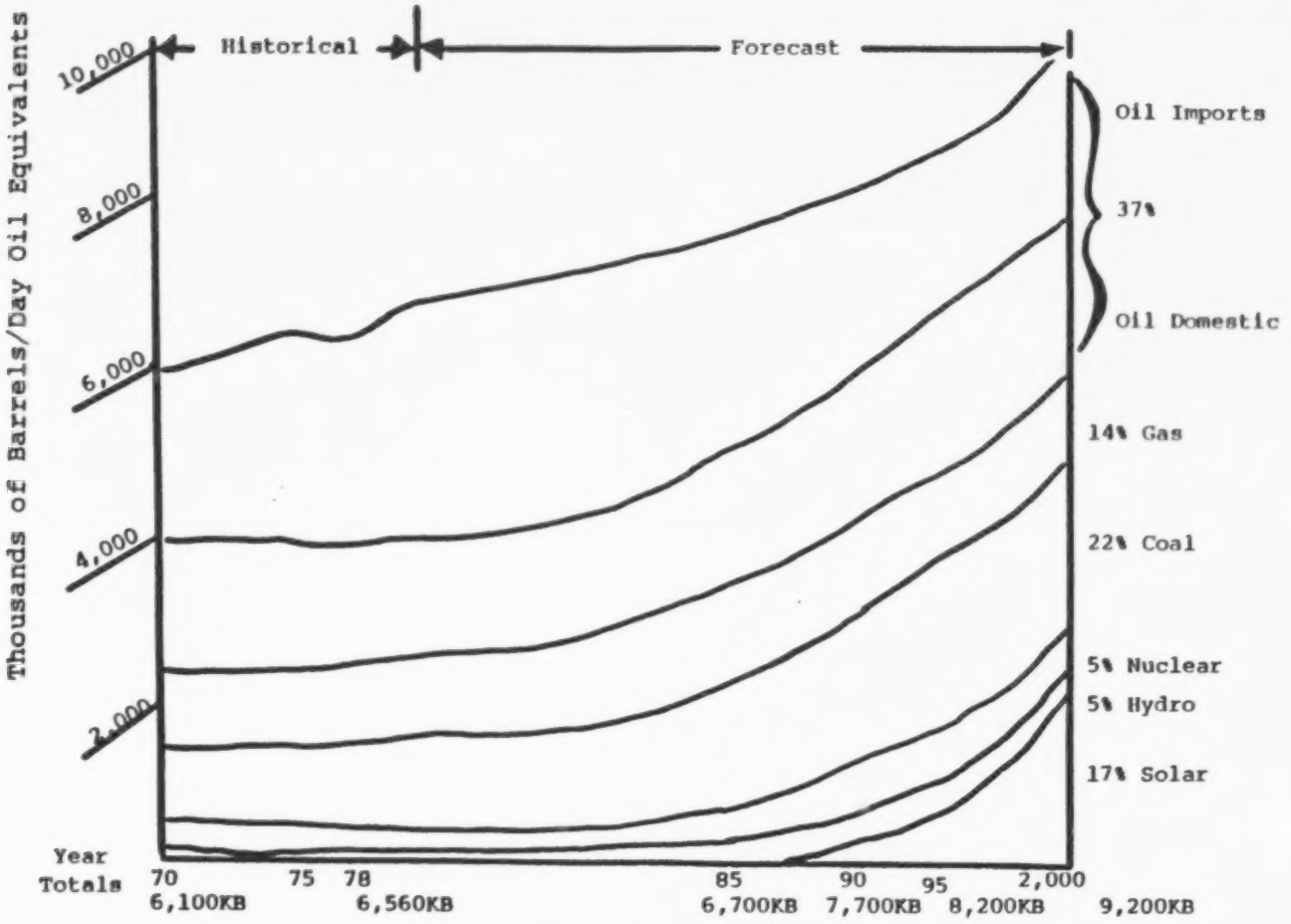
A cord of Air-Dry wood equals	Tons of Coal	Gallons of Fuel Oil	Therms of Natural Gas	Kilowatt hours of Electricity
1) Hickory, Hop Hornbeam (ironwood), Black Locust, White Oak =	0.9	146	174	3800
2) Beech, Sugar Maple, Red Oak, Yellow Birch, White Ash =	0.8	133	160	3500
3) Poplar, Black Willow, Aspen, Hemlock, Spruce =	0.5	86	102	2200
4) Basswood, White Pine, Balsam, Fir =	0.4	73	87	1900

ENERGY COMPARISON WET WOOD VS. DRY

Wood seasoned 12 months	100% Fuel Value
Wood seasoned 9 months	95% Fuel Value
Wood seasoned 6 months	90% Fuel Value
Wood seasoned 3 months	85% Fuel Value
Fresh cut green wood	63% Fuel Value

Adapted from Burning Wood, Northeast Regional Agricultural Engineering Service, Cornell University, Ithaca, New York.

TRANSPARENCY #3



Gross Energy Mix-Supply/Demand Balance
North East Region

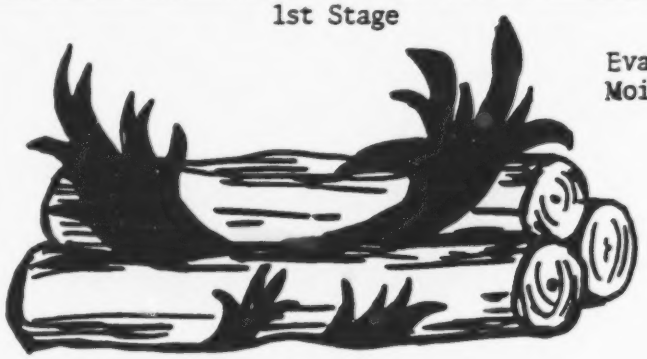
Adapted from Northeast Solar Energy Center,
Boston, Mass.

TRANSPARENCY #4

Stages of Combustion

1st Stage

Evaporates
Moisture



2nd Stage

500°F
1100°F

3rd Stage

over
1100°F

Charcoal

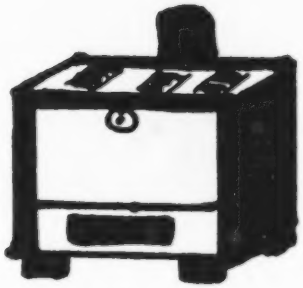
TRANSPARENCY #5

QUALITY CHARACTERISTICS OF COMMONLY BURNED WOODS

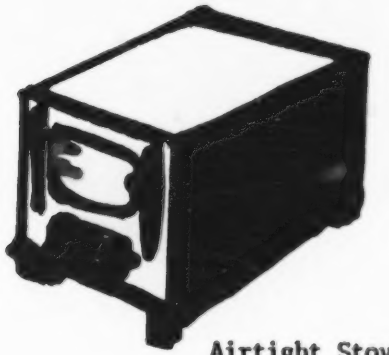
SPECIES	EASY TO SPLIT	EASE OF STARTING	HEAVY SMOKE	SPARKS	COALING QUALITIES
Ash	yes	fair	no	few	good
Beech	no	poor	no	few	good
Birch (white)	yes	good	no	moderate	good
Cherry	yes	poor	no	few	excellent
Hemlock	yes	good	medium	many	poor
Hickory	yes	fair	no	moderate	excellent
Locust (black)	no	poor	no	very few	excellent
Maple (sugar)	yes	poor	no	few	excellent
Oak (red)	yes	poor	no	few	excellent
Pine (white)	yes	excellent	medium	moderate	poor
Spruce (Norway)	no	good	yes	moderate	poor

Adapted from Burning Wood, Northeast Regional Agricultural Engineering Service, Ithaca, New York.

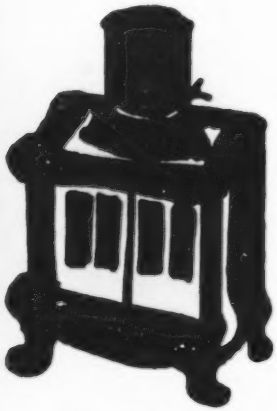
Types of Stoves



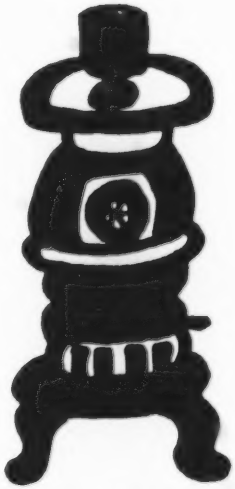
Circulating Stove



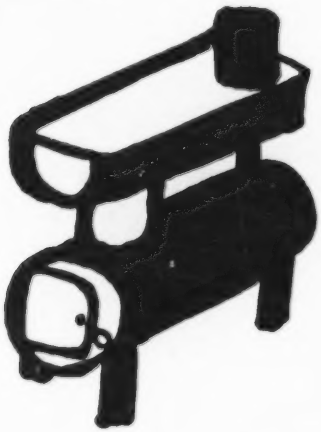
Airtight Stove



Franklin Stove
(non-airtight)



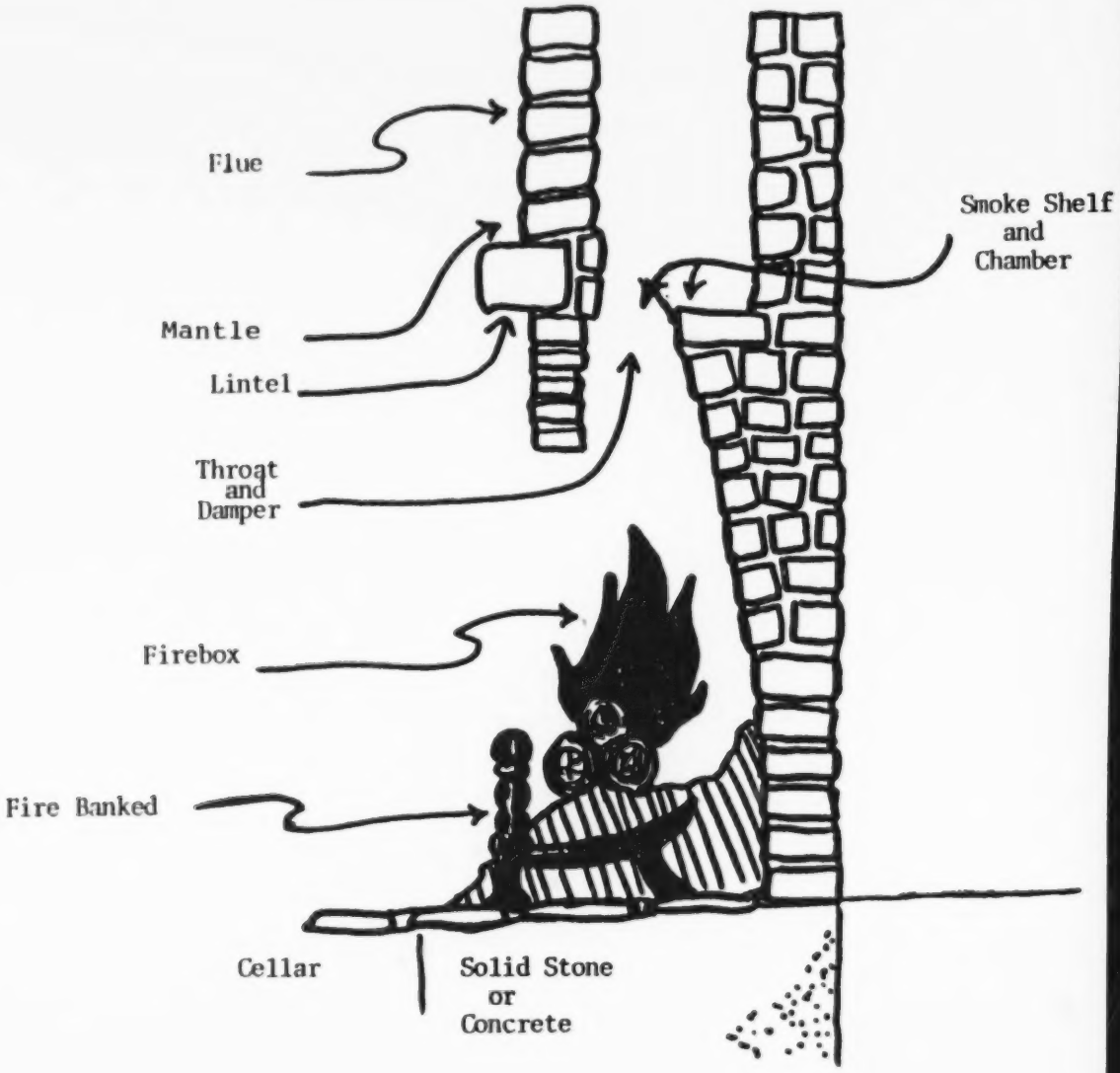
Pot Belly Stove



Double Chamber Stove

TRANSPARENCY #7

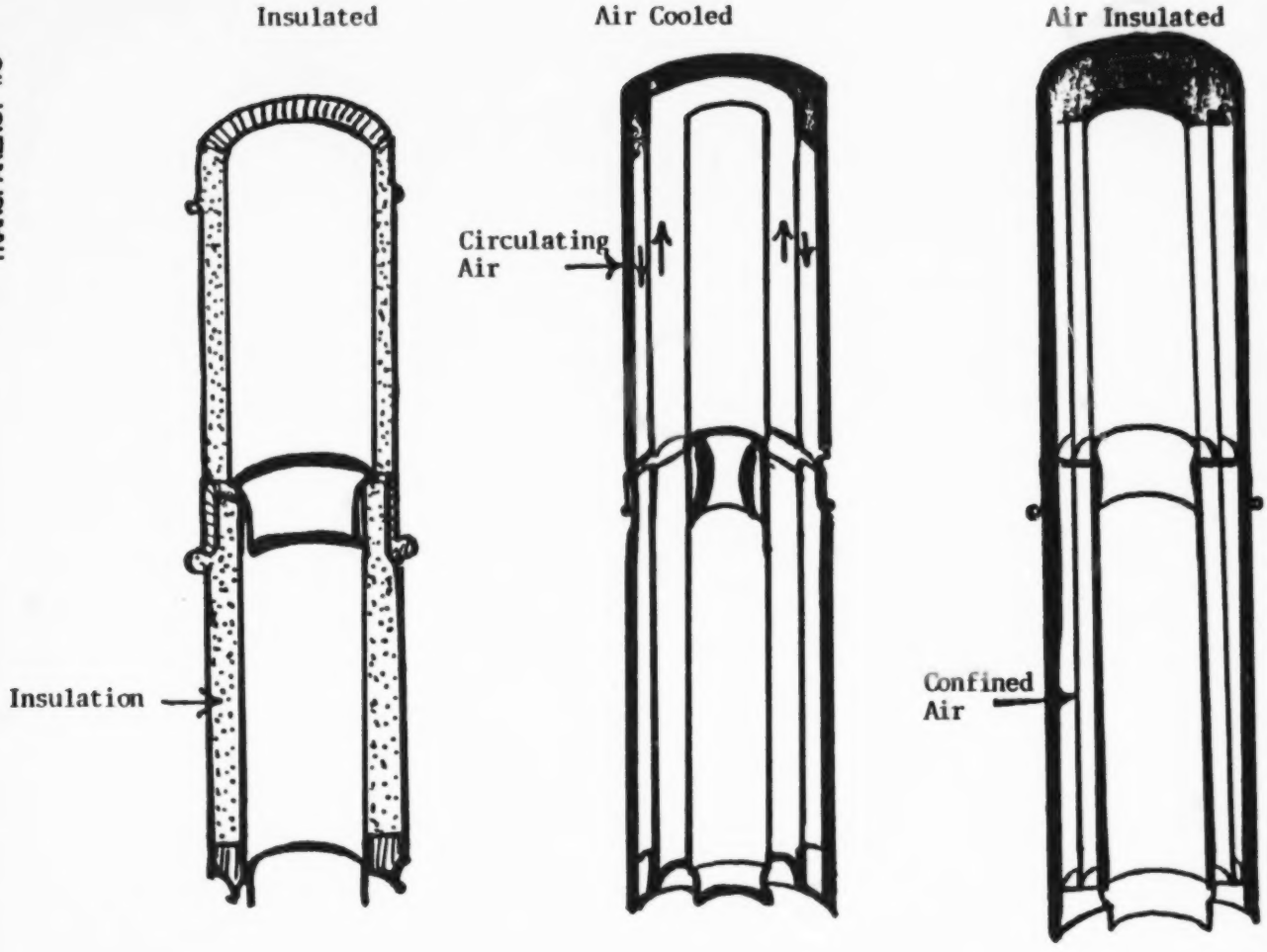
RUMFORD DESIGN



Adapted from Wood Heat, Vivian, 1978.

TRANSPARENCY #8

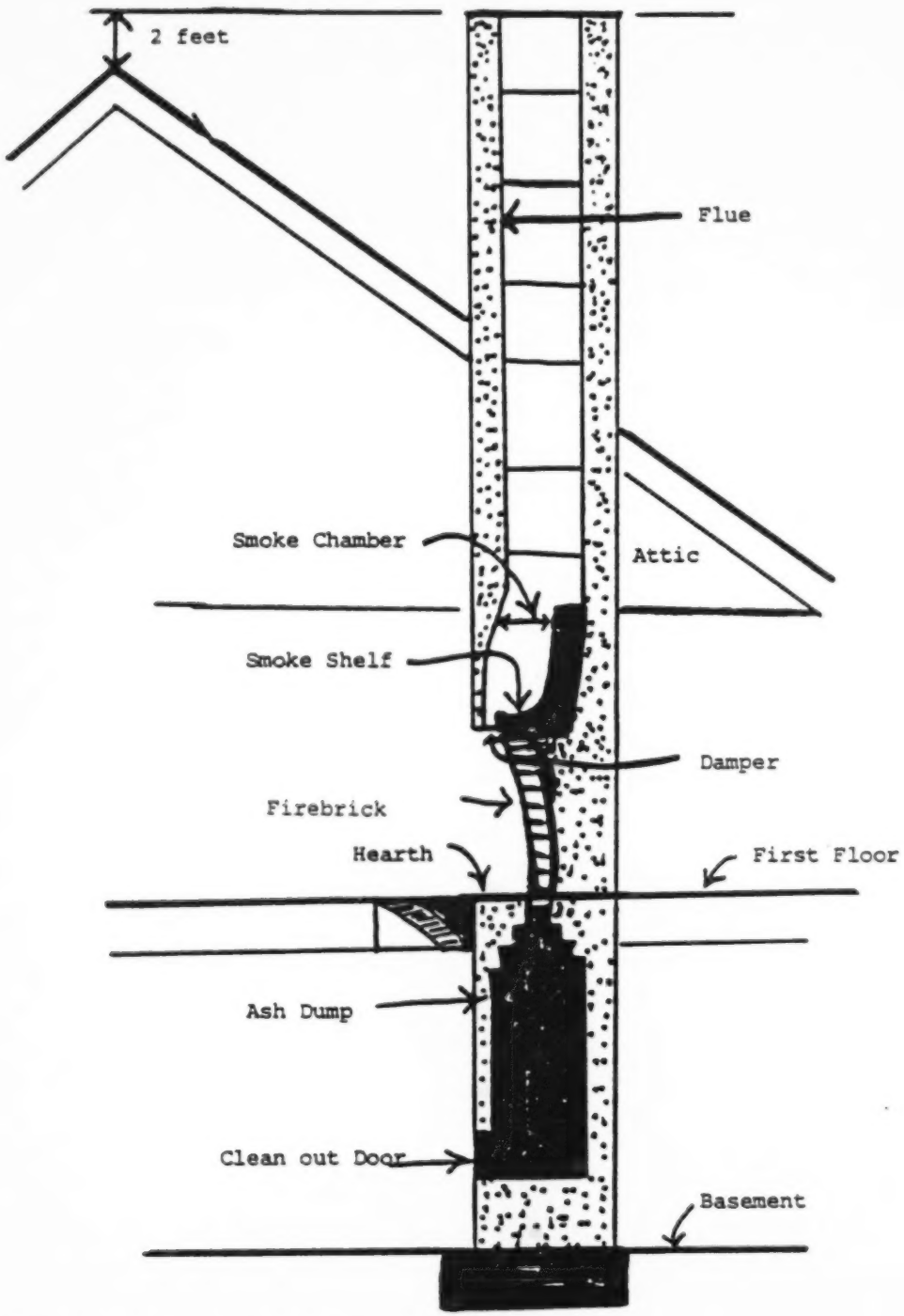
TYPES OF METAL CHIMNEYS



Adapted from Wood Heat Safety, Shelton, 1979.

TRANSPARENCY #9

MASONRY CHIMNEY



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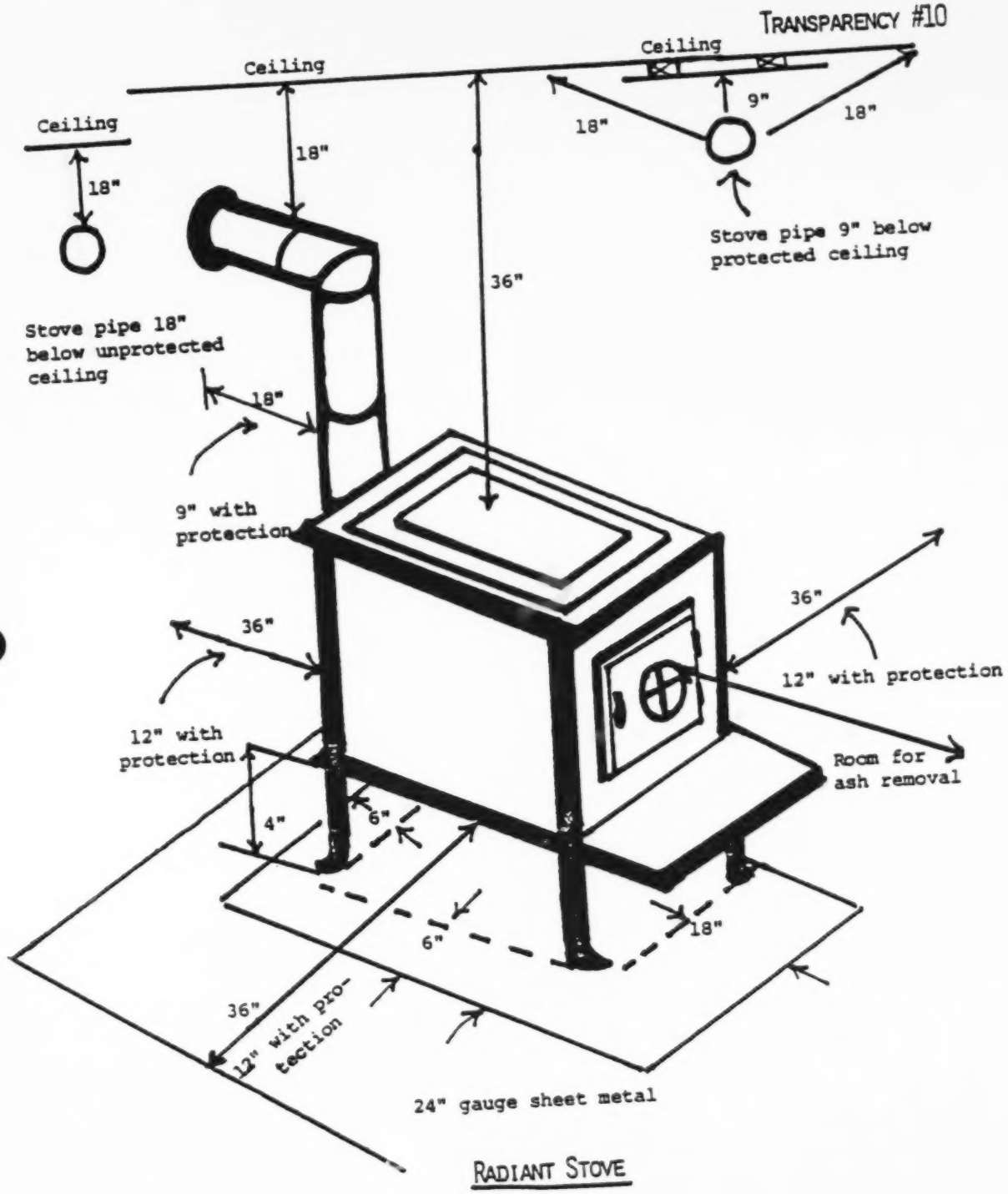
TRANSPARENCY #10



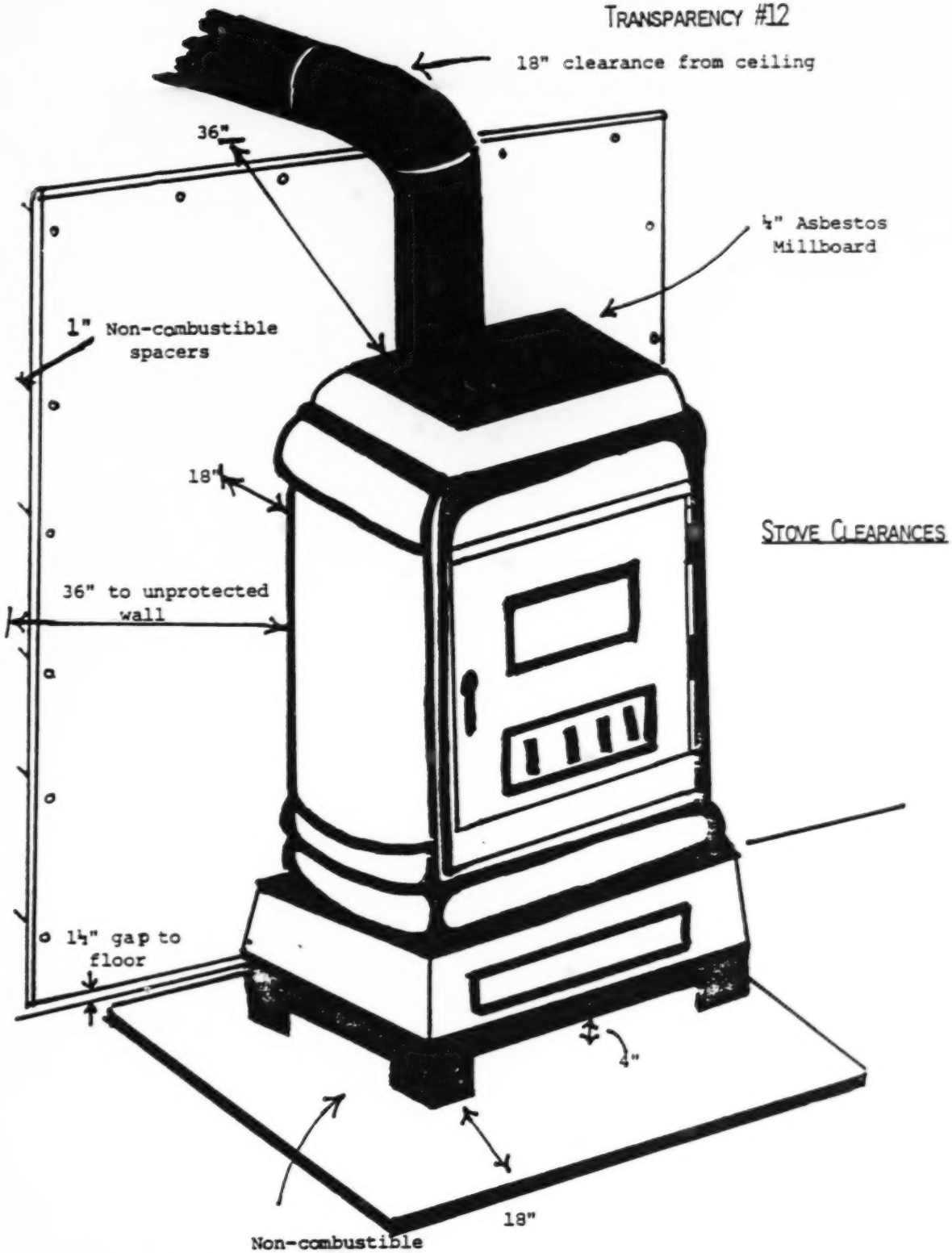
RADIANT STOVE

Chimney Height

Transparency #11

Adapted from Wood Heat Safety, Shelton, 1979.

TRANSPARENCY #12

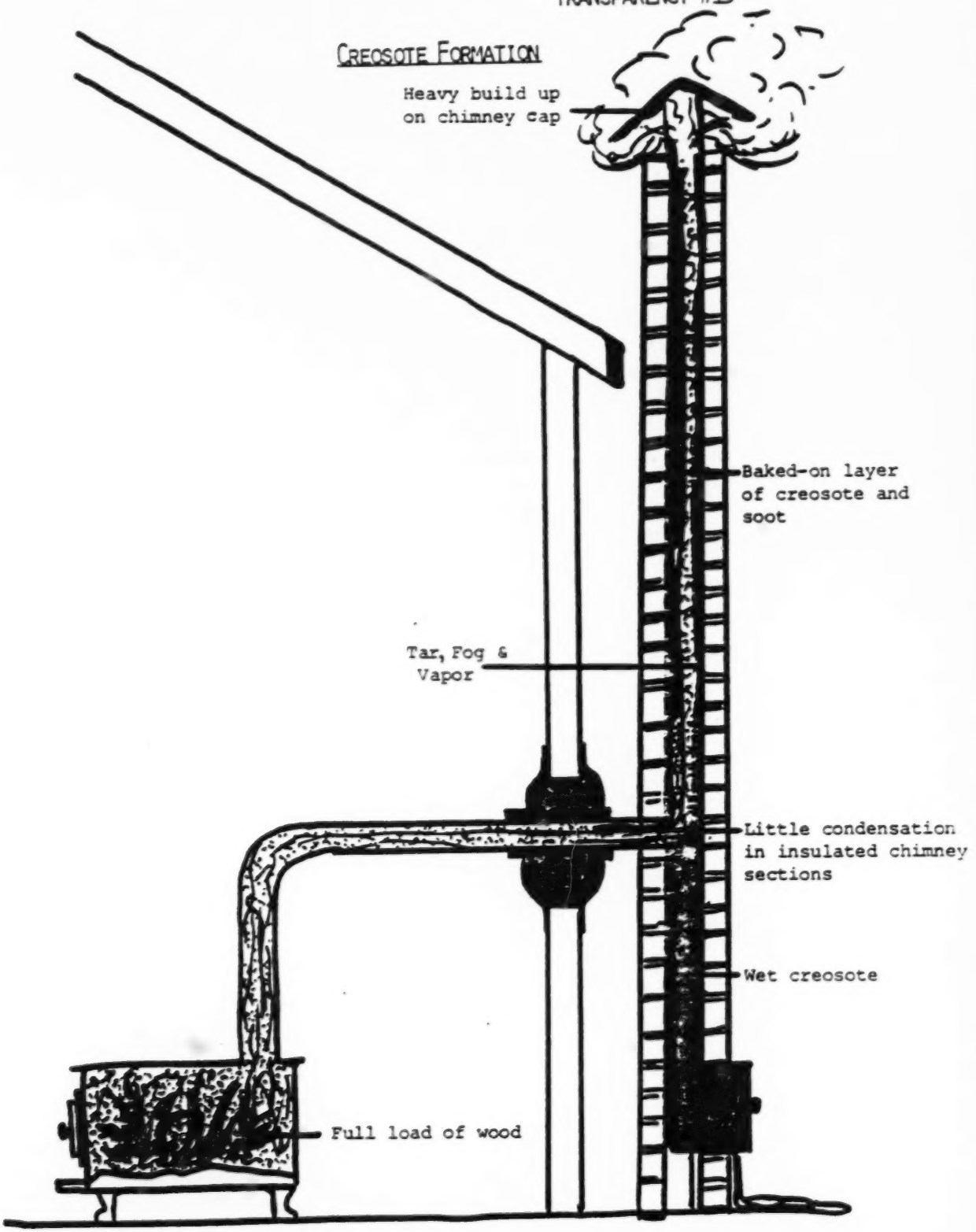


STOVE CLEARANCES

Adapted from Burning Wood, Northeast Regional Agricultural Engineering Service, Ithaca, New York

TRANSPARENCY #13

CREOSOTE FORMATION


Heavy build up on chimney cap
Baked-on layer of creosote and soot
Tar, Fog & Vapor
Little condensation in insulated chimney sections
Wet creosote
Full load of wood

Adapted from Wood Heat Safety, Shelton, 1979.

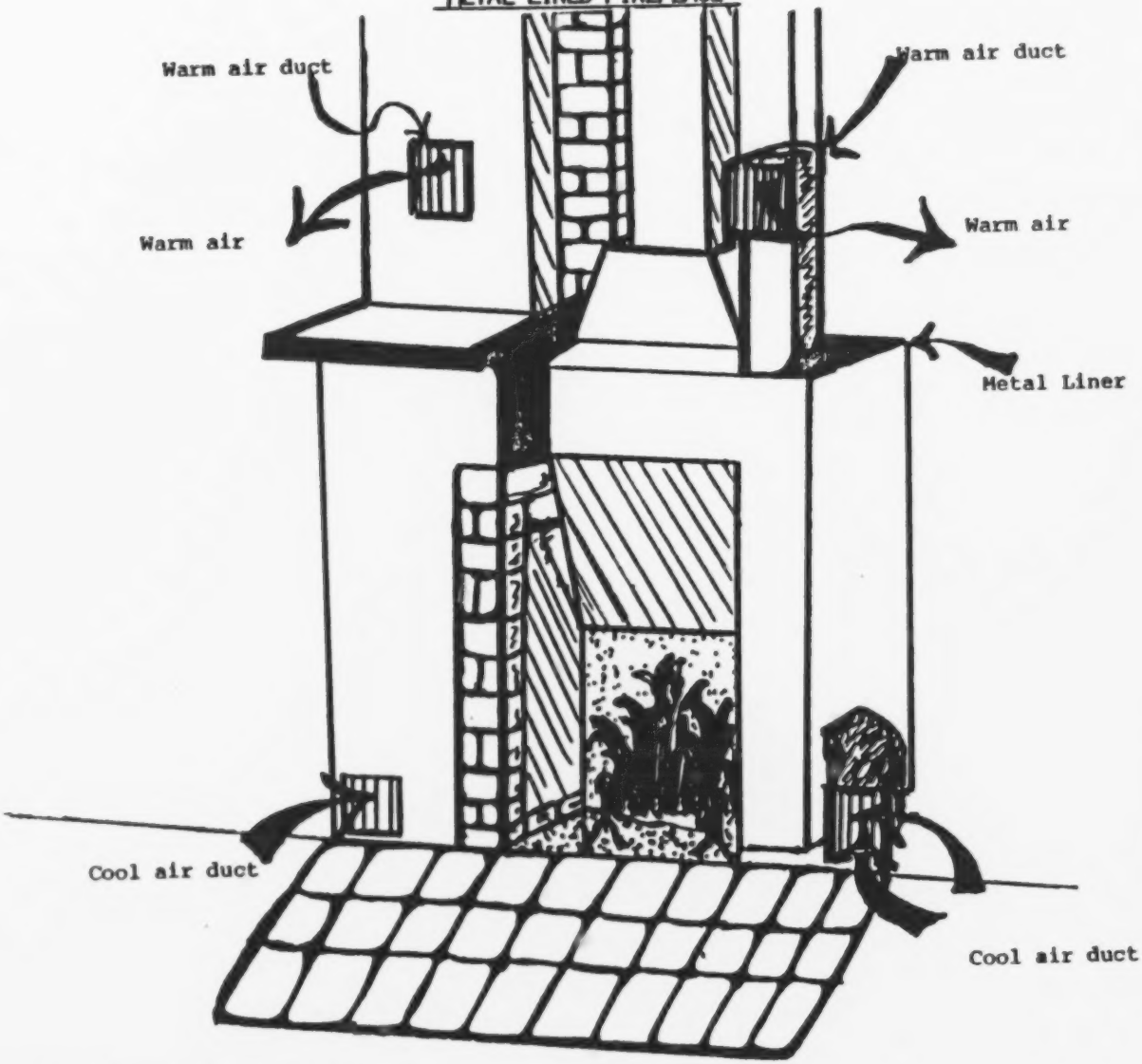
TRANSPARENCY #14

A STUDY OF 60 FIRES

CAUSE OF FIRE	# OF FIRES	TOTAL COST
Improper clearance	13	$190,581
Defective chimney	13	142,898
Chimney fire	11	12,875
Fireplace sparks	8	21,321
Defective masonry fireplace	3	3,600
Barrel stove	2	7,933
Smoke damage due to poor draft	2	209
Exterior cement block chimney	1	28,000
Improper homemade device (other than barrel stove)	1	20,000
Space heater in mobile home	1	7,750
Defective ash pan	1	5,730
Improper disposal of ashes	1	1,500
Use of lighter fluid to start fire	1	510
Defective smoke pipe	1	196
Improper operation	1	35
	60	$443,138

TRANSPARENCY #15

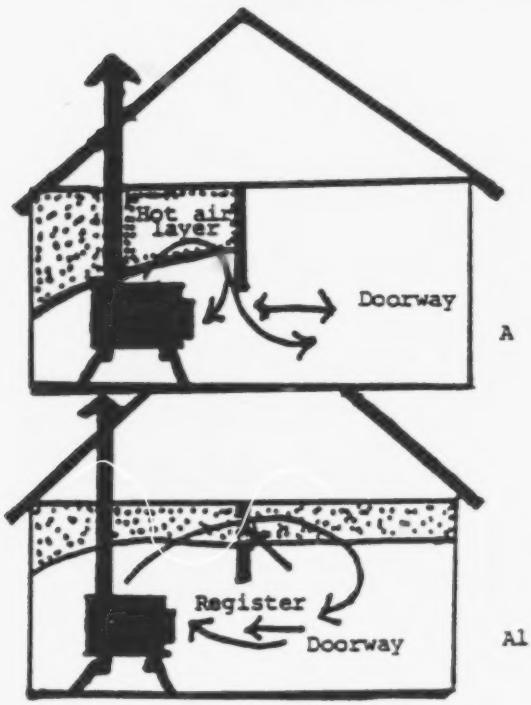
METAL LINED FIREPLACE



Adapted from Burning Wood, Northeast Regional Agricultural Engineering Service, Ithaca, New York.

TRANSPARENCY #16

STOVE LOCATION AND HOT AIR FLOW



A

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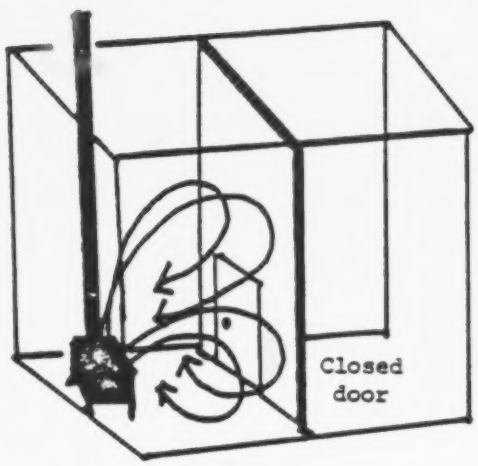

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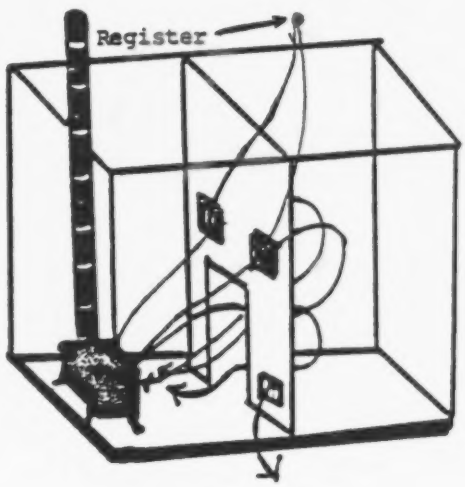


B1 Possible cold air return

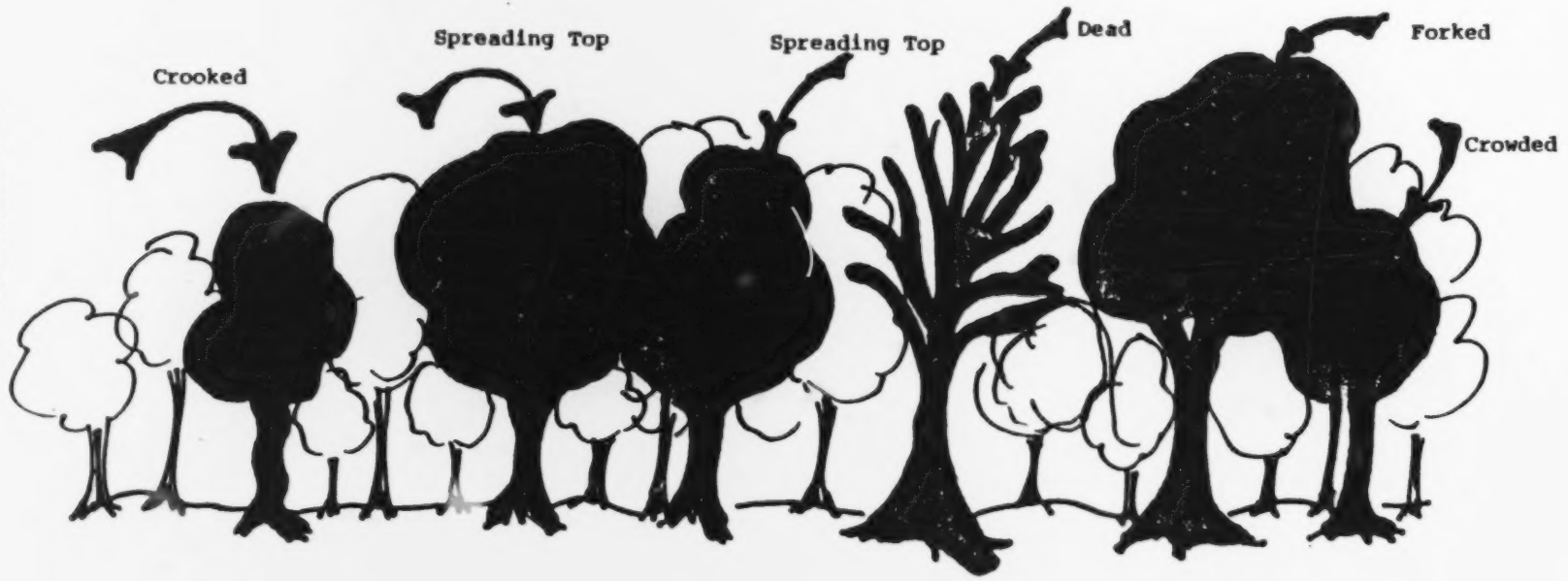
Adapted from The Woodburners Encyclopedia, Shelton, 1978

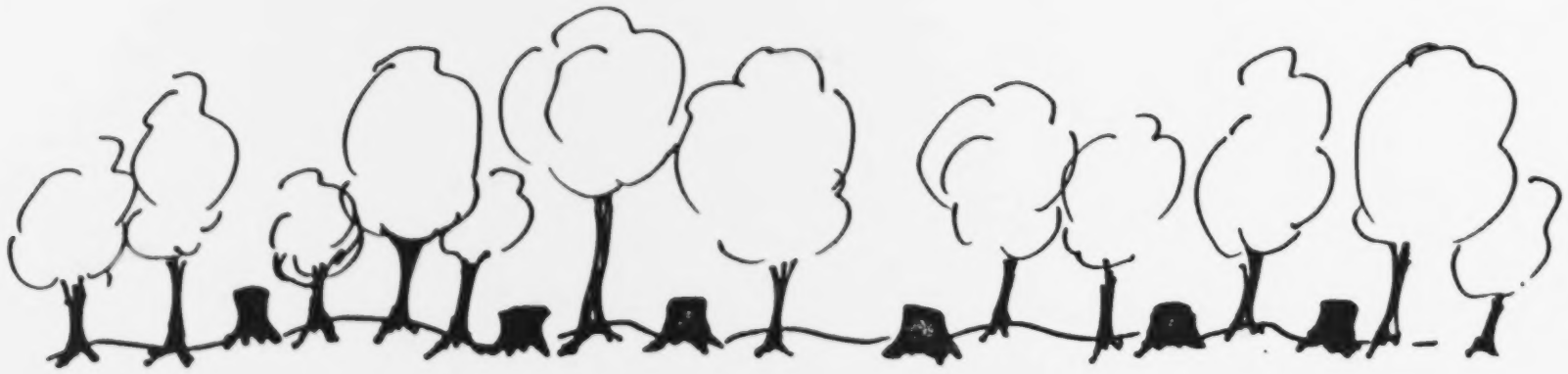
TRANSPARENCY #17

PER CENT MORE HEAT FROM AIR-DRIED WOOD			
SPECIES	GREEN BTU's	AIR-DRY BTU	% MORE HEAT
Ash	16.5 million	20.0 million	21%
Aspen	10.3 million	12.5 million	25%
Beech, American	17.3 million	21.8 million	26%
Birch, Yellow	17.3 million	21.3 million	23%
Hickory, Shagbark	20.7 million	24.6 million	19%
Maple, Red	15.0 million	18.6 million	24%
Oak, Red	17.9 million	21.3 million	19%
Oak, White	19.2 million	22.7 million	18%
Pine, White	12.1 million	13.3 million	10%

Improve Value of Woodlot While Gathering Fuelwood

Transparency #18





After fuelwood cutting

Adapted from Burning Wood, Northeast Regional Agricultural Engineering Service, Ithaca, New York.

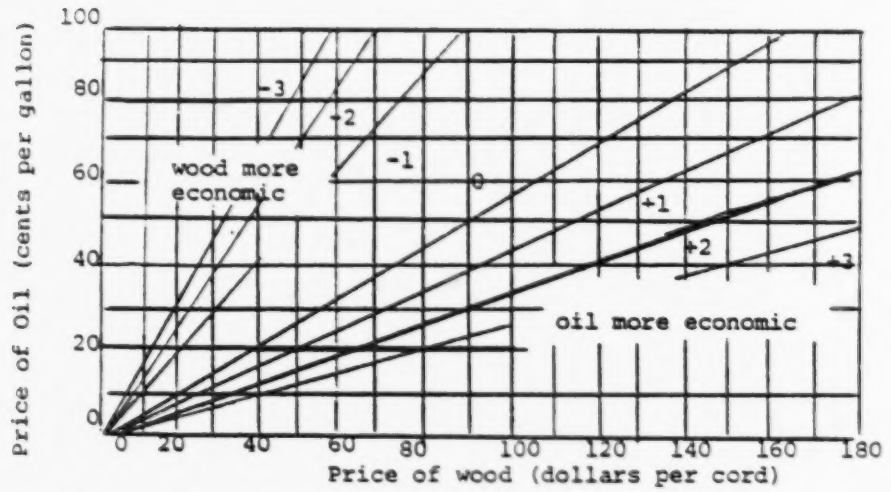
TRANSPARENCY #19

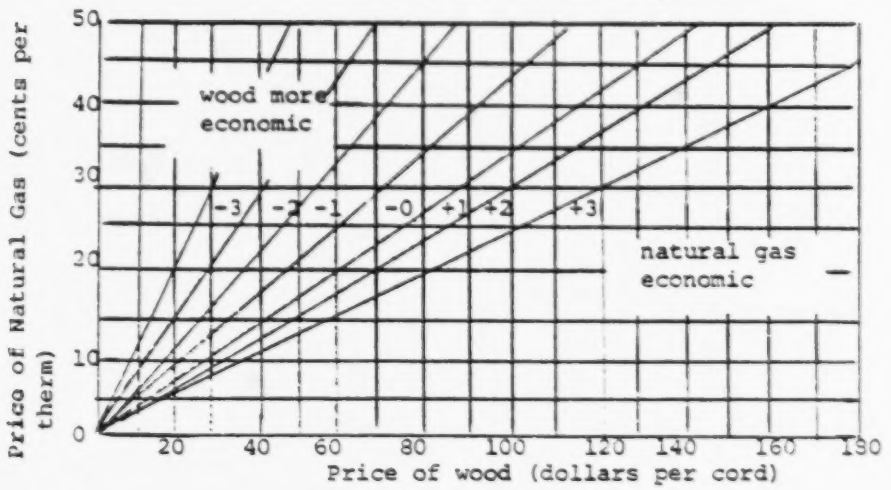
A CORD OF AIR-DRY WOOD EQUALS	TONS OF COAL	GALLONS OF FUEL OIL	THERMS OF NATURAL GAS	KILOWATT HOURS OF ELECTRICITY
Hickory, Hop Hornbeam (ironwood), Black Locust, White Oak, Apple =	0.9	149	174	3800
Beech, Sugar Maple, Red Oak, Yellow Birch, White Ash =	0.8	133	160	3500
Gray and Paper Birch, Black Walnut, Black Cherry, Red Maple, Tamarack (Larch), Pitch Pine =	0.7	114	139	3000
American Elm, Black and Green Ash, Sweet Gum, Silver and Bigleaf Maple, Red Cedar, Red Pine =	0.6	103	123	2700
Poplar, Cottonwood, Black Willow, Aspen, Butternut, Hemlock, Spruce =	0.5	86	102	2200
Basswood, White Pine, Balsam Fir, White Cedar =	0.4	73	87	1900

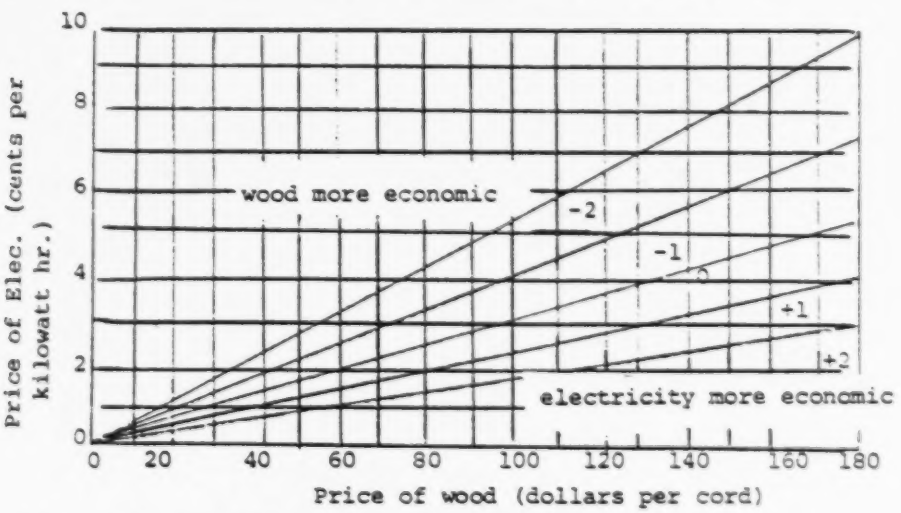
Adapted from Burning Wood, Northeast Regional Agricultural Engineering Service, Ithaca, New York.

TRANSPARENCY #20

ECONOMICS OF WOOD VS. TRADITIONAL FUELS







Adapted from The Woodburners Encyclopedia
Shelton, 1978.